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FIFTY-FOURTH ANNUAL REPORT

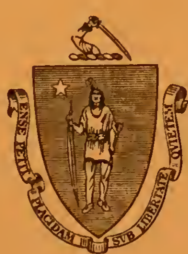
OF THE

MASSACHUSETTS AGRICULTURAL COLLEGE.

PART I.

REPORT OF THE PRESIDENT AND OTHER OFFICERS OF ADMINISTRATION

FOR FISCAL YEAR ENDED NOV. 30, 1916.



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The Commonwealth of Massachusetts.

Massachusetts Agricultural College,
Amherst, Dec. 1, 1916.

To His Excellency Samuel W. McCall.

Sir: — On behalf of the trustees of the Massachusetts Agricultural College I have the honor to transmit herewith, to Your Excellency and the Honorable Council, Part I. of the fifty-fourth annual report of the trustees, for the fiscal year ended Nov. 30, 1916, this being the report of the president of the college and other officers of administration to the corporation.

I am, very respectfully, your obedient servant,

KENYON L. BUTTERFIELD,
President.

REPORT OF THE PRESIDENT OF THE COLLEGE.

Gentlemen of the Corporation.

I herewith submit my annual report as president of the Massachusetts Agricultural College, and with it transmit reports from the other administrative officers of the institution.

AN ADEQUATE PLAN OF FINANCIAL SUPPORT FOR THE MASSACHUSETTS AGRICULTURAL COLLEGE.

The most serious question which the college has to face at the present time is that of sufficient and permanent financial support. Many problems of teaching, investigation, administration, courses of study, are being carefully studied by the staff of the institution; but in nearly every instance the individual or the committee which is considering any one of these problems discovers that its final solution is largely dependent upon sufficient funds.

Since 1900 the college has not only grown steadily in enrollment of students, but there has been an even more striking development in the range and scope of its varied activities. Recent legislative appropriations for current maintenance have not been niggardly. The resolve passed by the Legislature of 1913 granting a five years' appropriation for maintenance, increasing progressively each year, was gratifying not only because of the amounts involved but even more because it has enabled the college to plan with some degree of system and foresight. Nevertheless, a considerable proportion of the advantages gained by this resolve were vitiated by the fact that not only was no equivalent provision made for permanent improvements, such as buildings, but that it has been necessary to pay for certain permanent improvements out of current funds, — a plan wholly indefensible from the standpoint

of good accounting, and unfortunate in that it drew heavily on funds sorely needed for other purposes.

Although enlarged appropriations for current support are much needed, provision for permanent improvements is perhaps just now our chief financial question. The college for years was woefully lacking in adequate buildings. Indeed, the material equipment of the college for the first thirty-five years of its history was really pathetic in its meagreness. Up to 1900 the college did not possess a single building of brick or stone planned for or adapted to teaching purposes. The three wooden structures then in use for teaching are now inventoried at less than $20,000; one of these, erected in 1867, still serves as an excuse for a chemical laboratory; a fourth wooden structure, the drill hall, was built about 1883. Several departments were given extremely meagre accommodations in one of the dormitories. As late as 1904 the little frame "botanic museum" of one story and with two or three small rooms upstairs accommodated all the horticulture, all the botany, as well as the treasurer. Since 1904 several modern and well-equipped brick buildings have been added, but, even so, only one really large building has been built in the history of the college, namely, Stockbridge Hall, which houses the various departments of the Division of Agriculture. Other large buildings, such as a library, a chemical laboratory, an armory and gymnasium, should be built at once. The present housing for these features of our work is little short of disgraceful, and would not be tolerated in an endowed institution of any standing whatever. *The college is to-day at least ten years behind its proper building program.* We could amply justify an immediate expenditure of a million dollars for buildings.

An Agricultural College and Nothing Else.

The action of the Legislature in appointing a Commission on Agricultural Education apparently raised no questions concerning the fundamental purpose of the college. It seems to be assumed that the college is solely an agricultural college. But I am persuaded that many legislators and citizens do not appreciate the scope of the work of a modern agricultural college, nor the great need for trained, paid leadership in

agricultural affairs. The insistence by some that the college should graduate only working farmers shows a lack of vision of the present and future needs of agriculture. Yet it seems clear that both the people and the Legislature assume that we are an agricultural college and nothing else. At any rate, that is our assumption. We may err in our methods of getting results, but we are loyal to agricultural advancement as the main task of the college. It hardly seems necessary to reiterate this fact.

Still, there is more or less agitation for a State university in Massachusetts. Informally, and largely from individuals, suggestions are occasionally made that this college might be the nucleus for such an institution. A variation of this proposal is that our college should offer preparation for many other fields than agriculture and country life, — become both in fact and in name "The Massachusetts State College." Doubtless the Morrill Act of 1862 gives ample legal warrant for either policy. Aside from the institutions for colored students, 22 of the "land-grant" institutions are either State universities or are attached to State universities established prior to 1862, while 26 are agricultural and mechanical colleges separate from State universities. In Massachusetts, at the very outset, "mechanic arts" was taken over by the Massachusetts Institute of Technology. The Massachusetts Agricultural College stands unique among the sisterhood of public institutions of higher learning established by the Morrill Act of 1862 in that it is not connected with a State university and that it deals with agriculture alone. It is the only institution of collegiate grade in America which may be called strictly an agricultural college and nothing else.

Whatever Massachusetts may decide with reference to new State-supported educational institutions of higher grade, I trust that the Massachusetts Agricultural College may be left to develop as an agricultural college solely, with funds sufficient to place and keep it in the very front rank of agricultural colleges. There are unique advantages in a policy of exclusive devotion to the rural problem. The field is wide enough for all our energies and important enough for warranting our best efforts.

In my report for 1911 I dwelt at some length upon the purpose of the college as I interpret it, emphasized our desire to keep it strictly an agricultural college, and stated strongly our opposition to any movement that may seek to work it over into a State university. I hope that the present statement may set forever at rest any intimations or suspicions that our purpose is to make of this institution anything else than a college of agriculture.

The Argument for Support from the Standpoint of the State.

Sometimes I fear that it has become the habit of the Legislature to think of the college as in a sense a beggar, or at least a suppliant for State aid. On the other hand, it may be possible that college officers concern themselves too little about what the State can afford. There can be no doubt that the real test of the need of an educational institution is its service to the State. In our case it may be asked, first, to what extent is the institution serving the State? Secondly, in view of this service, how much can the State afford to spend upon that particular type of service?

The support of an agricultural college must be viewed largely as a matter of productive investment on the part of the State. The annual value of the agricultural production in Massachusetts will soon be in the neighborhood of a hundred million dollars. In this day of scientific study, any corporation that did a business of a hundred million dollars a year would, I am sure, think it a very modest investment if it devoted one-fifth of one per cent. of its annual product each year to investigations concerning improvements in its business. Individual farmers cannot make elaborate investigations. Practically the only place where these can be made is at the agricultural college. The State is in some sense a corporation doing its business in agriculture through individual farmers who own the land and do the work. It might be desirable if this annual value could be taxed so that a portion of it would be used for investigational work, but that is impracticable. The State must consider itself as the beneficiary of increased agricultural productivity, and should invest money in agricultural investiga-

tion. This small investment of one-fifth of one per cent. of the annual value of agricultural products in Massachusetts would yield $200,000 a year for study of agricultural problems, as against the $30,000 now appropriated by the State for this purpose.

Let us look at the matter of support from another point of view. Suppose the college eventually costs the Commonwealth a million dollars a year. This would mean, at the present assessed valuation of the State, that a citizen whose property is assessed at $5,000 would contribute $1 a year for the support of the college. If the college is in any measure efficient in its work, is there any citizen of the Commonwealth who would be imposed upon if he made a contribution on this basis?

Consider the general value of the State-wide educational work which the college carries on. No one can measure the money value of such an educational work or put it in terms of dollars and cents. We can only point out some of the returns that come to the Commonwealth. The test of our usefulness to the State is not alone our usefulness to the farmer. We serve the entire Commonwealth for such reasons and in such ways as the following: —

1. By helping urban communities to gain an adequate food supply, through larger productivity of the land and through better quality of products.

2. By assisting in securing economical means of food distribution, so that both producers and consumers will be benefited thereby.

3. By aiding, to an increasing degree, workingmen who wish to live on the land while still earning wages in some industrial occupation.

4. By assisting in the development of agricultural educational values for the children of the Commonwealth. It is doubtful if the people of the State realize the educational gains that came to the children in the schools of the State last year when nearly 50,000 boys and girls were enrolled in agricultural clubs of various sorts.

5. By assisting in securing a better farm life, as a part of the common life of the State. If the college does its work well, it will assist materially in the upbuilding of well-developed

rural communities, and thus help in maintaining a better type of people on the land.

For such reasons as these the Commonwealth, in its support of an agricultural college, makes a definite investment that gives real, even if not easily measured, returns to the State as a whole. I do not stop here to urge the fundamental value of the college to agriculture itself, to the farmers and their families. That value is here assumed. Too seldom do we urge the fact that the college is an asset of the State as a whole.

As a practical question, it should not be forgotten that for various reasons the income from Federal grants for agricultural college work is not relatively so great in Massachusetts as it is in most other States. The reasons for this do not need to be presented at this point, but the fact remains and has a bearing upon the extent to which the State, in order to do as well by its agricultural college as other States do, must make up the deficiencies in Federal appropriations.

Needs from the Institutional Point of View.

Our report of a year ago discussed rather fully our needs for permanent improvements. These may be reviewed very briefly here.

1. *Land.* — Through the acts of the last Legislature the college is now enabled to purchase, out of current funds, certain much-needed parcels of land on which it has had options for some years; but it is perfectly clear that as the years go by the college will need considerably more land. The experience of all agricultural colleges has demonstrated that an institution of this sort can hardly have too much land. More and more the land is used for laboratory or educational purposes, as well as for demonstrations, tests and experiments. We should have from five to ten thousand dollars a year for some years to come, to use for land purchases as the situation dictates and as the trustees may determine. The experiment station alone should acquire during the next five or six years not less than 125 or 150 acres of land. Even a cursory examination of its present areas demonstrates that they are ridicu-

lously inadequate. I call your attention to the very clear and emphatic statement of Director Brooks in his report (see page 60) on this point.

2. *Buildings.* — I am sure that one who carefully surveys the equipment of the college must agree that the situation amply justifies large expenditures for buildings within the next two or three years. As one prominent citizen of the State phrased it not long ago in looking over the decrepit building that at present houses our department of chemistry, "It is a disgrace to the State." He was nearly as emphatic with respect to the existing library facilities. It will prove difficult, if not entirely impossible, to take advantage of the new congressional act relative to military drill unless we have a new armory. For at least five years we have cherished the hope of soon affording adequate physical education for every student in college. It is quite out of the question even to attempt such a development without a new gymnasium. Some important departments of the college, such as English, for example, have no headquarters. The department of economics has been moved half a dozen times in as many years, and to-day has no abiding place. It is obvious that the best work cannot be done under such conditions. The housing of students becomes more unsatisfactory every year. We are asking the Legislature this year, for the seventh time, for a dormitory. The college was organized and was carried on for thirty years on a dormitory basis. Fewer students are accommodated in dormitories than was the case twenty years ago, when the college had only one-sixth the number of students it has to-day.[1]

3. *Miscellaneous Improvements.* — There is constant need for minor improvements of various kinds, for new equipment for teaching and practical purposes, and for the replacement of the more expensive equipment. These additions should not be charged against current maintenance. They add to the in-

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[1] Buildings needed at once and in near future: completion of power plant, library, chemistry building, armory and gymnasium, completion of infirmary, completion of rural engineering shops, completion of laboratory for physics and microbiology, service building for pomology, remodeling Stockbridge house and cottage, greenhouses (floriculture), market-garden buildings, horticulture (miscellaneous buildings), poultry building, rural arts building for department of landscape gardening, administration building, building for humanities and rural social service, buildings for women (domestic science laboratory), dormitories for men and women.

ventory of the institution, and should be provided out of funds set aside for that purpose. Unfortunately, it has become necessary during the past two or three years to encroach upon our current income for the making of certain improvements and the purchase of equipment absolutely necessary for the work of the institution.

The sum of $200,000 a year for some years to come, certainly for not less than six, should be regarded as a minimum sum for buildings and other permanent improvements at the institution.

Maintenance.

Investigation. — Permanent agricultural improvement is based on scientific investigation. The State of Massachusetts is now contributing something like $30,000 a year for this purpose. Some States are contributing five or six times as much. The State of New Jersey spends twice as much annually for its experiment station as does Massachusetts. Massachusetts should provide its experiment station, in the not distant future, with an annual appropriation of not less than $100,000 a year for investigational work, including an adequate study of the agricultural resources, conditions and needs of the Commonwealth. Scores of important problems await study.

Extension Service. — Under the five years' appropriation for current purposes there was a "gentleman's agreement" that not to exceed $50,000 annually should be spent for the Extension Service of the college. This sum has proved entirely insufficient for growing demands. We have been obliged to postpone indefinitely a number of very important lines of work for lack of funds. A good illustration of this is in our failure to provide instructors for the non-English speaking farmers who are rapidly filling up various parts of Massachusetts. They are both farmers and potential citizens. They can be reached for the present only in their own language. We have cherished the hope for a half-dozen years that we could put at least one man into the field to help these people. The director of the Extension Service has annually called attention to new lines of work that are in demand but

that we are unable to take up. I feel very strongly that we should have, in the not distant future, a total of at least $100,000 a year for extension work in Massachusetts, and of this at least $75,000 a year should be provided from the State treasury.

General College Purposes. — We need increased funds for the following purposes: —

1. As the college grows and as we add to its building equipment, the cost of maintenance of the physical plant will, of course, increase, and this, too, entirely apart from the probabilities of increased cost of labor, coal and other supplies. Just at present this last factor is one of considerable financial importance. We estimate that the Saturday half-holiday law for laborers alone has increased the labor expense by $5,000 a year.

2. It is generally admitted that the salaries of college teachers are inexcusably low. There is a movement all over the country to raise these salaries nearer to their proper amounts. Especially do we need larger salaries for teachers as contrasted with administrators. A recent investigation by the dean of one of our great agricultural colleges shows that while Massachusetts is doing reasonably well with its instructors and assistant professors, its professors and associate professors are among the lowest paid in the country, at least in the dozen or fifteen leading agricultural colleges. We have done our best, under our financial limitations, in regard to increase of salaries at this college, but, considering the cost of living, it is doubtful if the average professor has as large a real income as he had ten or fifteen years ago.

3. New instructors must be taken on as the number of students increases. In our college increase of students does not give increase of income, because we have no tuition.

4. A few new departments should be established, as, for instance, a department of horticultural manufactures and a department, or its equivalent, in history and government. We need additions to our work in rural social science, and particularly do we desire facilities for the instruction of women students, both in agriculture and in home economics.

5. Nearly all of our departments in agriculture and horticulture need more teachers, especially in advanced work. Many of these departments are undermanned.

It is possible that some saving can be made by cutting down the number of courses in modern languages and in mathematics, and it is even possible that we are offering too many courses in some of the science departments, but economies of this sort cannot be very pronounced and would not begin to meet such needs as have just been stated. A fairly constant increase of 5 per cent. per year for maintenance purposes should be regarded as an absolute minimum, and indeed it is all too little for the development of the work that is necessary to make the institution of the largest possible service to the Commonwealth.

Methods of Finance.

For many years the financial needs of the institution were met by a small annual grant for maintenance of the institution and by special grants for permanent improvements. All through the history of the college it has been necessary to go to the Legislature for increases in maintenance funds and for new buildings. The Commission on Economy and Efficiency in 1913, under the leadership of Mr. Norman White, its chairman at that time, recommended very strongly indeed that the finances of the college be put on a permanent basis. His plan was carried out only in part. The result was a five years' appropriation for maintenance, with a progressive increase each year. This has proved very satisfactory except for the fact, already mentioned, that it has been encroached upon because for two years the Legislature failed to provide funds for improvements and equipment. Mr. White's original plan contemplated an appropriation large enough to include the erection of buildings. Two years ago and again last year bills embodying this idea were introduced into the Legislature. Both years the bill received the cordial support of the committee on agriculture. Last year the executive committee of the State Grange, the college committee of the Board of Agriculture, and a special committee of the alumni of the college

visited the institution and gave some study to its needs for buildings and equipment. Each of these groups strongly favored a substantial six years' appropriation for permanent improvements. The present Commission on Investigation has before it the arguments for this plan.

Some Principles of Finance for the College.

There are a few things that seem to be fundamental in a satisfactory financial policy for the college.

1. There should be a permanent financial policy. It is highly important that the institution may know its resources and plan accordingly. I am convinced from conferences with reputable contractors that a substantial saving, for example, could be made in building contracts if these contracts could be made in the winter instead of in midsummer, and the buildings erected during good weather rather than in the dead of winter.

2. Permanent appropriations should be progressive in amount, otherwise it is impossible for the institution to grow or even to maintain itself, as the number of students increases and the number of buildings to be maintained becomes larger.

3. The necessity of presenting the college case before the Legislature each year consumes a great deal of time that ought to go into the real work of the institution. Neither the president nor any other officer of the institution does any "lobbying." Nevertheless, the presentation of these matters before the proper committees, the preparation for these committee hearings, and even the very fact of uncertainty as to results are all factors in the consumption of time and energy. It is wholly wise that the institution should be required to give an account of its work to the Legislature, but it is highly uneconomical and unbusinesslike for the administrative officers of the institution to be compelled to use so large a proportion of their time as is now necessary in simply trying to secure necessary funds.

It is sometimes said that no Legislature should "commit future Legislatures" to expenditures for support of the college. This phrase sounds well but it does not mean much. The facts are that whenever a Legislature establishes a State insti-

tution it commits the Commonwealth for all time to come to a reasonable support of that institution. It is interesting to know that this very question with respect to the Massachusetts Agricultural College has been passed upon by the Supreme Judicial Court.[1] Referring to the acceptance by the Legislature of the provisions of the Federal Morrill Act of 1862, and of the grants thereby made to the State, the court said: —

> But the acceptance of the gift or grant for a public purpose of this nature, especially with the conditions attached to it by the act of Congress, involved the assumption by the State of certain duties and burdens which it was bound to perform and discharge. The gift was not an absolute one. It was upon certain trusts expressly set forth and declared, to the execution of which the State became solemnly pledged. No part of the funds derived from the sale of lands granted by the United States could be expended in the erection of buildings, and only a small portion thereof in the purchase of land. But expenditures of money to a large amount for these purposes were essential to the creation and establishment of the college which the Commonwealth was, by the act of Congress, bound to provide within five years from the date of the acceptance of the grant of land. This, therefore, was a public burden or duty which the Commonwealth had taken upon itself and was bound to discharge, in order that it might faithfully execute the trusts which it had assumed, and thereby enable the people of the State to enjoy the benefits which were expected to flow from the bounty of the national government.

In other words, the Commonwealth is forever "committed," indeed, "solemnly pledged," to support the college.

Furthermore, the Legislature is constantly "committing" future Legislatures in other ways. The present appropriation for highways is an example. Bond issues, in cases where the bonds are afterwards to be taken up and the debt paid, are examples of a little different type. Indeed, any bond issue commits the State irrevocably to the payment of interest on those bonds. It is further to be said that in the case of an appropriation bill for the support of the college that covers a period of years, it is perfectly competent for any Legislature to repeal that legislation. It seems to me that the argument for not committing future Legislatures has no adequate foundation, either in theory or in practice.

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[1] Merrick *v.* Inhabitants of Amherst, 12 Allen, 500.

How can these Financial Principles be applied?

1. The present progressive maintenance appropriation might be continued for another five years; the resolve expires with the year 1918.

2. In addition, there might be made a five or six years' appropriation for improvements, say at the rate of $200,000 a year.

3. These two plans might be combined into one act, which would make, say, a five or six years' appropriation for all purposes.

4. The State might issue bonds for the erection of a certain number of buildings. California, for example, this last year voted a bond issue of something like two or three million dollars for its State university. This plan of bond issues might work especially well with dormitories. In my judgment dormitories could be made to pay interest on the bonds.

5. The money for the college might be raised on the basis of the so-called mill tax, which is not after all a tax but merely a method of determining the amount of income. Not less than fifteen States support wholly or in part their State educational institutions in this way. The valuation of the real and personal property subject to local taxation in Massachusetts is now approaching the amount of $5,000,000,000, and the amount of this valuation has increased in recent years somewhere in the neighborhood of $150,000,000 a year. An appropriation equal to twelve one-hundredths of a mill upon each dollar of assessed valuation would give the college nearly $600,000 a year for all purposes, and presumably an increase of something like $20,000 a year for an indefinite period. The mill tax is ideal provided it is large enough to begin with, and provided the basis of assessment remains fairly constant, so that there will never be either big decreases or big increases.

I do not care to argue here at length for any one of these plans; they are stated in the briefest way, merely to afford a basis for discussion of details.

In Conclusion.

In thus discussing the general question of financial support for the college I have been obliged to cover ground which has been gone over in former reports. May I say also that after all these years of service on the part of the college it would almost seem unnecessary to take so much time to discuss or to lay so much emphasis upon the mere question of adequate and permanent support. Surely the Commonwealth after fifty years should have made up its mind on this point. Unfortunately, however, as I intimated at the beginning of this discussion, this very question is the most important that we have before us. The most cursory examination of our needs must convince any one that we face a critical situation. It is due the college and its staff that some decision as to permanent support be reached at once.

Respectfully submitted,

KENYON L. BUTTERFIELD,
President.

THE REVIEW OF THE YEAR.

Changes in Trustees.

At the close of his administration Governor Walsh appointed Mr. James F. Bacon of Boston to succeed Mr. Arthur G. Pollard of Lowell as trustee of the college. Since the retirement of the late M. F. Dickinson the Board has felt the need of a legal adviser among its members. The selection of Mr. Bacon has proved to be a fortunate one.

Soon after the death of Mr. William H. Bowker, Governor McCall appointed Mr. Arthur G. Pollard of Lowell to fill the vacancy; thus the Board will continue to benefit by the experience gained by Mr. Pollard through his years of service on the Board.

During the year, owing to the resignation of Dr. David Snedden, Commissioner of Education of Massachusetts, Dr. Payson Smith, by virtue of his succession to Dr. Snedden, becomes a member of our Board of Trustees. We are glad to welcome him to our number.

Changes in Staff.

Dr. George E. Stone retired from active service Sept. 30, 1916. Dr. Stone was connected with the college and experiment station from 1895, having been head of the department of botany and in charge of the research work in this subject. Dr. Stone was possessed of marked natural talent and ability as an observer and investigator, and his scientific work has been characterized by originality, ingenuity and enthusiasm. He has been one of the most fruitful workers of the institution, and possessed unusual ability to arouse the interest and enlist the co-operation of advanced students, whose work along selected lines and under his guidance was made contributory to the working out of broader problems which had engaged his attention.

At the end of June, Prof. Sidney B. Haskell left the institution to take up work as soil expert with the soil improvement committee of the National Fertilizer Association. It was with deep regret that we felt obliged to accept his resignation.

Since Professor Haskell's graduation from this college in 1904 he has been connected with the institution, first as assistant in the experiment station, later as instructor in agronomy, and for five years head of the department of agronomy. Although teaching a subject in which he was obliged to establish his own standard for perfection, and in which but a limited amount of material had been assembled by others, he made a distinct reputation for himself as a teacher and organizer through his high ideals of scholarship and genuine teaching ability. He elevated the work of his department to a plane second to none in any department of the institution. We have not yet succeeded in discovering a man who we are satisfied will continue the work in agronomy on the same high plane of efficiency as that established by Professor Haskell.

During the summer Prof. Orion A. Morton accepted a position as agent for the Massachusetts Board of Education. Professor Morton came to this institution four years ago to organize the boys' and girls' agricultural clubs throughout the State. In this work he was eminently successful, so that there are boys' and girls' agricultural clubs in 315 cities and towns of Massachusetts. These clubs comprise a membership of about 50,000, probably the largest enrollment of any State in the Union. This achievement is really a stupendous one numerically and a momentous one educationally. We regret that Professor Morton found a more attractive call elsewhere.

Mr. George L. Farley succeeds Prof. O. A. Morton as supervisor of junior extension work. Mr. Farley is a graduate of Dartmouth College, from which institution he also has the degree of master of science. He has had eighteen years' experience as a teacher of grammar schools and as school supervisor, in these capacities serving in the following towns and cities: Hanover, N. H., Hyde Park, Mass., Cambridge, Mass., Brookline, Mass., New Haven, Conn., and Brockton, Mass. It was under Mr. Farley's administration as superintendent of the Brockton schools that the boys' and girls' club work in that city developed so successfully. Coming as he does with a wide experience and acquaintance with school work, and with ability as an organizer and administrator, the

continued success of this extremely important phase of our work seems to be assured.

Mr. Earnest D. Waid has resigned his position as assistant director of the Extension Service. Mr. Waid has been connected with our Extension Service since September, 1911, coming to us with several years of successful experience in similar work and in teaching at other agricultural colleges and universities. While here, Mr. Waid's special work has been that of organizing and supervising the extension schools, fair exhibits, lectures and lecture courses, and the winter ten weeks' course. Mr. Waid has been a faithful, industrious and efficient member of the Extension Service staff, and it is with regret that his resignation has been accepted. Mr. Waid will sever his connection with the institution in the early spring, and devote his full time to the development of his farm in Amherst.

Mr. E. F. Damon was in the winter of 1916 secured to fill the vacancy caused by the death of Prof. R. H. Ferguson, in extension work in agricultural economics. Mr. Damon graduated from the Massachusetts Agricultural College in 1910. Following a year's graduate work in agricultural economics at the University of Wisconsin, he spent nearly five years in the west in various agricultural co-operative enterprises. Just prior to taking up his work at Amherst he was manager of one of the largest fruit growers' exchanges in southern California.

Charles H. Patterson succeeds Henry E. Smith as assistant professor of English. Professor Smith has rendered for four years most acceptable service; cultured, highly trained, exceedingly industrious, he gave us his best. Professor Patterson is a graduate of Tufts College, and has studied at Chicago University. He has had a long and successful experience in high school teaching and in administrative work. The principal schools with which he has been connected are the Boston School of Expression, the West Virginia University, and Dean Academy as principal.

John T. Wheeler has been elected assistant professor of horticulture. With the introduction of a larger amount of agriculture and horticulture to the curriculum required of

freshmen and sophomores it became necessary to provide additional instruction in horticulture as well as in agriculture. Professor Wheeler is a graduate of the University of Wisconsin, also of the State Normal School at Mansfield, Pa. He has had several years' experience as high school principal and as supervisor of schools. At this institution he will assume large responsibility in connection with the direction of the freshman agriculture and horticulture.

Reorganization of the Department of Botany.

The department of botany has been reorganized during the year, with Prof. A. Vincent Osmun as head of the department. Professor Osmun graduated from this institution in 1903 and received his master's degree here in 1905. Since the latter date he has been continuously connected with the institution as an investigator and teacher.

Attendance.

The enrollment in the present freshman class is 170; a year ago the number was 211. The total enrollment, however, of all students in work of college grade is 680, as compared with 668 a year ago, the increase being about 1.8 per cent. The reason for the substantial falling-off in the size of the entering class has not been satisfactorily established; doubtless a number of causes contributed to this result. One cause, which apparently has considerable foundation, is, that some students, who were planning to enter this year, decided to wait until another fall because of the fact that this year they were able to obtain work at high wages, thus making it easier for them to finance their college course at a later date. The total number of young women students is constantly increasing; 6 entered in this year's freshman class, making a total enrollment of 28. (See Table V. for analysis of enrollment.)

Commencement.

The annual Commencement Day exercises were held Wednesday, June 21. The degree of bachelor of science was conferred on 100 men and 2 women; 5 candidates received the degree

of master of science and 3 the degree of doctor of philosophy. The alumni dinner was attended by 223 alumni and officers of the college. President Kenyon L. Butterfield delivered the Commencement address, his subject being "The New Rural Advance." In this address he reviewed briefly the significant achievements in agricultural education during the past ten years, and ventured certain predictions as to future development.

Fiftieth Anniversary.

Plans are maturing for the fiftieth anniversary of the opening of the college. The dates decided upon are October 7 to 10 inclusive. The following program has been voted by the executive committee in charge of the celebration and by the trustees. Work is progressing on the brief history of the college and on the bibliography. Mr. William C. Langdon has been chosen as the pageant master, and is now on the grounds developing his plans for the pageant.

Provisional Program, 1917 Celebration.

Sunday, October 7:

- 3.00 P.M. Outdoor Commemorative Program, Pageant Grounds.

Monday, October 8:

- 10.00 A.M. Dedication of the Athletic Field.
- 2.30 P.M. Foot Ball Game.
- 5.00 P.M. Alumni Dinner and Program.
- 8.00 P.M. Undergraduate Night.

Tuesday, October 9:

- 10.00 A.M. Addresses by Delegates.
- 12.00 M. Class Reunions.
- 1.00 P.M. Luncheon to Delegates.
- 3.00 P.M. Pageant.
- 8.00 P.M. Formal Reception by the Governor, the Trustees and President.
- Fraternity Reunions.

Wednesday, October 10:

- 10.00 A.M. Meeting of Association of American Agricultural Colleges and Experiment Stations.
- 12.30 P.M. Outdoor Dinner.
- 2.00 P.M. Anniversary Speaker.
- 3.30 P.M. Pageant.

The Four-term Plan.

Last September the college opened on the plan, formerly developed and duly approved, of dividing the year into four terms, including a summer session. While as yet the plans for the summer course are not entirely matured, it is probable that beginning next year a start will be made in giving summer instruction.

The Graduate Summer School, 1916.

On invitation from your Board, the graduate summer school of agriculture, conducted biennially by the Association of American Agricultural Colleges and Experiment Stations, was in 1916 held at the Massachusetts Agricultural College from July 3 to 28 inclusive. Dr. Charles E. Marshall was chosen to assist Dean A. C. True in the conduct of the school, and there was developed a most helpful program. The attendance was somewhat of a disappointment, but the character of the work given was of the best, and it was felt that it was entirely worth while for this institution to entertain the school. The total enrollment was 194, composed as follows: from the Massachusetts Agricultural College, 87; from other New England States, 41; from other States, 58; and from foreign countries, 8.

Scholarship and Character Records.

This year we have organized a small group of instructors who are serving in conjunction with the dean of the college as class advisers; one or two instructors are assigned to each class, and their function is to keep in constant touch with the scholastic standing of each student under their direction. By frequent conferences on scholarship matters or other problems of the student, it is possible to help the men in realizing to a fuller extent their opportunities here. With the younger men it is possible to enlist the co-operation of parents, wherever necessary, in maintaining a satisfactory scholastic grade in all subjects. The work thus accomplished seems to be entirely worth while, and already gratifying results have been observed.

The dean has during the year organized a plan for making rather systematic personality studies and keeping character records based upon opinions and statements made by the teachers.

Committee on Student Employment.

During the year there has been formulated by the faculty committee on employment a rather comprehensive plan for the appointment to permanent positions at the college of students who need to earn a portion of their college expenses. Student labor has been classified into three groups: skilled labor positions, permanent positions and irregular unskilled positions. Applications for these various positions are made either to heads of departments or to the committee, the heads of departments making the appointment, the committee passing on the need of the student for work, his ability, his classroom work, his character, etc. In this way the student labor at the college is being very thoroughly systematized.

Committee on Publications.

Growing out of discussions in the cabinet there has been organized during the year a committee on publications. The committee consists of the director of the experiment station, the director of the Extension Service, the director of the graduate school, the supervisor of correspondence courses, — who also has charge of the editing of Extension Service publications, — and the secretary of the college. The committee has undertaken to supervise the official publications of the college for the purpose of securing proper editing, institutional opinion in technical matters, avoiding duplication, and meeting public demand for various bulletins of a technical nature. Thus far the plan has worked successfully, and has accomplished some very useful and needed work.

Co-operation with the Board of Agriculture.

The State Board of Agriculture accepted the invitation extended by your Board to go into conference on the subject of co-operation between the two agencies. As you know, the

negotiations are not at this date completed, but they have gone far enough to indicate that it will be possible to agree upon the principle that the main function of the Board of Agriculture is administration and the main function of the college is education; and, further, that overlapping of work may be eliminated through the appointment of a joint committee of co-operation and through agreement upon written projects for new lines of work taken up by the one agency, that are likely to duplicate in any way the work of the other. This co-operation is most gratifying, and is in line with the best agricultural thought of the day.

The Massachusetts Agricultural Development Committee.

During the year the president has attended practically all of the monthly meetings of this committee. Both Dr. Cance and Professor Morgan have given much time and valuable service as special agents of the committee. Its work has demonstrated its usefulness. Two important and solid achievements have been gained during the year, one an agreement upon an outline of a comprehensive study of the agricultural resources, conditions and needs of the Commonwealth, — a study that will take years to complete but which may and should be begun at once. The proper division of labor in regard to carrying out this enterprise was also agreed to. The other achievement is the outlining and stating of the whole problem of agricultural development in the Commonwealth. There is still much work before this committee. Perhaps the most important single problem before Massachusetts agriculture to-day is that of thoroughgoing and comprehensive organization.

Additions and Improvements to Property.

The Legislature of 1916 granted an appropriation of $12,000 for three additional rooms to the present wing of the rural engineering building. This addition is almost completed and is being used by the department in the much-needed shop work.

The coal pocket, for which the Legislature also granted an

appropriation, was completed in the early part of October. We now have fairly adequate storage for our coal.

The usual repairs and improvements necessary to keep the buildings in good condition have been carried on during the summer.

The Legislature also granted the institution the right to purchase land, with the consent of the Governor and Council, up to the value of $20,000. It is understood, however, that not to exceed $5,000 a year shall be expended in each of the four years which the appropriation covers. We have purchased from John F. Dickinson the Leonard-Dickinson land, which lies to the south of the athletic field and gives the necessary space for added recreational facilities. The institution also secured a small tract of one-half acre of land from Mr. W. R. Brown, situated on East Pleasant Street, and the only parcel of land needed to make our line complete along that road.

The institution is greatly indebted to the heirs of the John L. Graves estate, to Mr. John F. Dickinson and to Mr. W. R. Brown for the interest they have taken in helping the college secure the different parcels of land in which they were interested.

The most notable addition is the building for the department of microbiology. The contract for this was let in the summer of 1915, but the building could not be occupied until October of this year. The delay was due almost entirely to the difficulty of securing the necessary material and labor. A brief description of the building follows.

The Microbiological Laboratory.

This building is unique in that its design is the result of the peculiar needs for the successful study of micro-organisms. It is fireproof throughout, with the exception of the roof boards and the hard maple floors, which are laid over the reinforced cement separating the different stories. The partition walls are brick and the ceilings are the facings of the reinforced cement floors finished and painted. There is no plaster on walls or ceilings anywhere in the building. The building is thus admirably adapted for the maintenance of cleanliness.

There are four laboratory class rooms. The one on the second floor is large and is designed for the general classes in microbiology; the one on the first floor will be used for dairy and food microbiology; and the basement has two, one for soil microbiology and one for hygienic microbiology. For recitation purposes there is a small class room located on the first floor. In addition to the above class laboratories, there are eight individual laboratories or research rooms, and a large library room on the first floor for consulting literature, reading and study. There is an office on each floor for instructors. The general office and clerical office are located near the entrance door on the first floor. There are five temperature rooms and a sub-basement or cellar room for the control of temperatures. There are three hood rooms, three sterilizing rooms and three wash rooms, one on each floor. The hood rooms, sterilizing rooms and temperature rooms are constructed about a shaft running from sub-basement to roof, which serves for purposes of special ventilation by means of small flues within the shaft, and also contributes to the safety of the building should an explosion occur. On each floor are also found a balance room and an inoculating room. In the basement, besides the other rooms mentioned, are a photographic room, an animal room, a furnace room, and a room in which the power apparatus is concentrated. Electricity, gas, hot and cold water, vacuum and pressure systems are distributed as needed throughout the building.

The building as a whole, therefore, is splendidly adapted to the teaching of and research in agricultural microbiology, and is probably one of the best arranged and equipped structures of its kind in the country.

Rural Engineering Shops.

The rural engineering building is a one-story structure 126 feet long and 68 feet deep, built with brick walls and concrete floors. The single story construction admits of the use of skylights, which make the building well adapted to shop purposes. The building has three large laboratories, used for carpentry, farm machinery and general farm repairs. A lumber storage room is adjacent to the carpenter shop and a tool room is

centrally located to the three laboratories. There are two offices and a locker room in the building. The portion of the building now completed forms two-thirds of the shop building planned for rural engineering.

The Mount Toby Demonstration Forest.

This tract consists of approximately 755 acres of timbered land, of which 721 acres are in the town of Sunderland and about 34 acres in Leverett. For a mile and a quarter it lies along the Central Vermont Railroad and includes the site of the old Mount Toby station, which is about 9 miles north of Amherst station. The forest composition is unique in that it is so representative of state-wide conditions. Every important forest type and combination of types found from the Berkshire Hills to the Cape are represented, and, what is even more rare, most of these types are found in every stage of development, from early youth to mature old age.

This is to be, as the name implies, a demonstration forest, and it will be the aim of the management to show by concrete example what scientific forest management, when actually applied to our Massachusetts woodlands, will accomplish. Just as the Massachusetts Agricultural College has been instrumental in bringing about improved farm management and production through experimentation and demonstration along those lines, so we hope by similar means to be instrumental in bringing about an improved forest management and production.

The Market-garden Field Station.

The effort made in the last Legislature by the Boston Market Gardeners' Association to secure appropriations for the purchase of land, the construction of buildings and equipment for experimental work in the interests of market gardening, and for its annual support, was only in part successful. The bill submitted by the association called for $25,000 for the purchase of land and the construction of buildings and equipment and $10,000 annually for maintenance. The Legislature granted only $8,000, which was to be used in the purchase of land. After a very thorough search on the part of

the trustees, with the aid and counsel of interested members of the faculty and of the officers of the Boston Market Gardeners' Association, the Board finally chose an area of about 12 acres in North Lexington, and the purchase is about to be consummated. Great credit is due to Prof. H. F. Tompson for his energy and skill in helping to bring this matter to a successful conclusion. A bill calling for an appropriation for buildings and maintenance will go before the Legislature at this next session. It will also be necessary for your Board of Trustees to adopt a definite plan of administration for this field station.

Publicity.

During the year we have been able to organize somewhat more effectively than formerly the publicity work of the institution. For several years we have desired to effect this organization because there is a growing demand on the part of the public for further information concerning the work of the college. Mr. Charles H. Gould, a graduate of the college in 1916, has been appointed field agent of the college, working under the direction of the secretary. He is devoting his time to lectures before high schools, granges and other bodies, organizing excursions to the college, publishing pamphlets, etc.

Legislative Appropriations.

Bills were presented to the Legislature of 1916 covering the following projects: (*a*) completion of power plant, $35,000; (*b*) library, $230,000; (*c*) extension of rural engineering shops, $12,000; (*d*) student dormitory, $40,000; (*e*) miscellaneous improvements and new equipment, $60,000; (*f*) extra labor on account of Saturday half-holiday, $5,000; our request for $30,000 for the purchase of the Mount Toby tract was also renewed. An attempt was made to secure a continuing appropriation for $200,000 a year for six years for buildings and other improvements.

We were gratified with the action of the Legislature in appropriating $30,000 for the purchase of the Mount Toby tract. The only other appropriations granted, however, were $20,000 for equipment and improvements, $4,200 for a retain-

ing wall at the power plant, and $12,000 for the extension of the rural engineering shops. The Legislature declined to grant the appropriation for the library and dormitory, and also to make the six-year appropriation.

The Investigation Commission.

The Legislature of 1916 authorized a commission to investigate the work of the college and other agricultural State agencies. The complete text of the law creating this commission and the scope of its work follows: —

Resolve providing for an Investigation by a Special Commission of Agricultural Education at the Massachusetts Agricultural College and the Development of the Agricultural Resources of the Commonwealth.

Resolved, That a special commission is hereby established, to be composed of the commission on economy and efficiency, the commissioner of education, and three persons to be appointed by the governor, with the advice and consent of the council, for the purpose of investigating the subject of agricultural education as conducted at the Massachusetts agricultural college and the development of the agricultural resources of the commonwealth.

The commission shall investigate and report as to the advisability of further expenditures for new buildings, additional equipment, the purchase of land and other improvements at the Massachusetts agricultural college; as to the present policy of the college, with a view to ascertaining whether the college is meeting in the fullest degree the needs of the commonwealth as to agricultural training; as to use of state and federal appropriations and grants; as to operation of farm department, in educational and academic instruction, and in the extension work; to find to what extent teachers are engaged in activities other than college instruction; to what extent students are taught practical farming; to what extent the college, independent of other agencies, contributes toward farming and agricultural development; to what extent the present acreage and present accommodations may be economically treated and utilized; to find the relative cost per capita for the education of state and out-of-state students in the various courses of instruction with comparisons with other agricultural institutions; to distinguish educational apart from other activities; to estimate cost of future development, if any, both for initial appropriation and for maintenance; elimination of other activities, revision of courses of study either in character, weeks of schooling, etc.; to ascertain what return, if any, is made to the commonwealth by graduate state educated students in the agricultural activities of the

people of the commonwealth; to ascertain what benefits, if any, can accrue to the welfare or development of agriculture in the commonwealth by co-ordination of the Massachusetts agricultural college, the state board of agriculture, forestry department and department of animal husbandry, or any of them; to the end that the report shall make a definite statement of existing conditions, specific recommendations for correction or improvement of existing conditions, that certain obvious existing duplications and overlappings of activities be eliminated and the departments herein referred to may be better co-ordinated and systematized into an effective administrative section of the commonwealth's efforts in behalf of its citizens.

The commission shall report what existing functions of agriculture, expenses for which are met by state appropriations, can best be carried on at the college rather than under the direction of the board of agriculture, and what functions now carried on at the college can better be performed under the direction of the board of agriculture.

The commission shall further report whether for the advancement of agriculture in Massachusetts it is advisable that the college be continued as at present organized.

The commission shall give public hearings, and shall be allowed for necessary expenses such sums as may be approved by the governor and council, not exceeding seventy-five hundred dollars. The commission shall report in print on or before January tenth, nineteen hundred and seventeen, and shall include in its report drafts of any bills necessary to carry out its recommendations.

Pursuant to the requirements of this law Governor McCall appointed the following as members of the commission: Dr. L. Clark Seelye of Northampton, Mr. Warren C. Jewett of Worcester and Mr. William L. Whiting of Holyoke; the two ex-officio members were Dr. Payson Smith, Commissioner of Education, and Mr. Charles E. Burbank, Supervisor of Administration. This commission organized with Dr. Seelye as chairman and Dr. Smith as secretary, and began its work in September. It has held a series of hearings, and the chairman has spent a large amount of time at the college. The college is indeed fortunate to have such an able body of men delegated to investigate its work. We have welcomed the investigation, and endeavored at every point to co-operate to the fullest extent with the commission.

THE IMMEDIATE NEEDS OF THE COLLEGE.

Legislative Budget, 1917.

The following legislative budget for 1917 has been approved by the Board of Trustees: —

Library,	$250,000
Equipment and improvements,	75,000
Poultry building,	4,200
Student dormitory,	50,000
Dining hall improvements,	10,000
Rural engineering shops,	9,000
Power plant, turbine house and steam line tunnels,	90,000
Total,	$488,200

Following is a brief statement of the need for the appropriations as requested: —

Library, $250,000.

In my report last year I dwelt at some length on the very pressing need for adequate library facilities. I can do nothing more this year than to reiterate those arguments, and to state that the need is even more apparent to-day than a year ago. The consensus of opinion among the college staff is that a new library represents the most pressing building need of the institution.

Equipment and Improvements, $75,000.

For three successive years the Legislature has made inadequate provision for much-needed improvements and new equipment at the college. The requests for this year, therefore, represent accumulated needs. A list of some seventy projects for improvements and of one hundred and fifteen projects for equipment have been submitted by members of the staff, and it is apparent that nearly all of these represent needs which should be met immediately. They cover various improvements on the campus, such, for example, as the construction of suitable walks and roads, and minor changes in buildings,

in order to bring the present facilities up to the growing demands made upon them. It is necessary each year to purchase additional equipment and to replace old equipment.

Poultry Building, $4,200.

The equipment for the poultry department is still far from complete, due in part to the fact that this work was undertaken in a large way only six years ago. A much-needed addition, which is being requested at this time, is a poultry breed and judging laboratory, 20 by 104 feet. The building here contemplated will provide a poultry house containing twenty-four small pens and laboratory space for general demonstrations; also a large room on the second floor adequate for the accommodation of twenty-five to fifty students in work in judging poultry.

Student Dormitory, $50,000.

This is the seventh successive year in which the college has asked the Legislature to provide funds for a small dormitory. Arguments for this building have been so fully and frequently presented that I will not restate them in this connection. I still feel, however, as evidently the Board of Trustees feels, as well as the students and faculty, that this is an extremely imperative need. At a time when student expenses are increasing materially, due to the high cost of living, it would be extremely desirable, from the standpoint of the college, to check the increasing living expenses in some small degree by affording comfortable living accommodations on the campus for a larger percentage of its students. The plan as presented will provide a dormitory to house fifty students, and estimates indicate that the building will pay a fair percentage on the investment represented, as well as provide rooms at a relatively low cost.

Dining Hall Improvements, $10,000.

When the dining hall was remodeled a few years ago, funds were not available for the construction of suitable storage facilities in the basement. The need for these has become more distressing each year, but no relief has been granted by the Legislature. The project as now outlined contemplates

the construction of a separate storage for potatoes, storage for one hundred tons of coal, and a complete refrigerating plant for meat, butter, eggs, fruit, etc.

Rural Engineering Shops, $9,000.

The Legislature of 1916 appropriated $12,000 for the construction of a one-story factory type of building for laboratory work and instruction in rural engineering. Whereas this provides the initial equipment for work in rural engineering, the building is not yet adequate. Accordingly, a request has been presented for the completion of these shops, and the expenditure here contemplated is for a unit 32 by 126 feet, providing a forge shop and an additional room for field machinery. By the addition of this unit we would be able to offer a complete course of instruction in the repair of farm equipment, including forge work. It will also enable us to bring together into one laboratory all the farm machinery used for instruction purposes. The work in rural engineering is appreciated by the students, and the large number who elect the courses are making unusual demands upon the department, particularly with respect to laboratory facilities.

Power Plant, Turbine House and Steam Line Tunnels, $90,000.

Owing to the buildings which have been erected at the college since the power plant was built, some eighteen years ago, the requirements made upon the plant have been increased many fold; thus, conditions at the plant are in need of prompt attention if efficiency in heating and lighting is to be rendered. In the boiler room there is at present no emergency equipment. We should have at least one spare boiler to meet possible emergencies. If new buildings are added, we should have the following additional equipment: —

- One 400 horse-power water-tube boiler.
- One stoker.
- One superheater.
- Coal-handling apparatus.
- Ash ejector.
- Additional flue.
- Feed pump.
- CO_2 machine.
- Draft gauge.
- Flue gas pyrometer.
- Return tank.

Minor changes in the construction of the present plant will be involved in the installation of this apparatus. The total cost of this equipment will be approximately $36,000.

It has been found that the institution can generate its own electricity at a cost which represents a material saving over the price which would be paid if purchased outside of the college. The present room used for the turbine is much too small. With the additional demands made upon the lighting system, due to new buildings, another dynamo is necessary, and it is proposed to install this in a separate turbine house, to be constructed north of the present power plant. The cost of the turbine house, dynamo, switchboard and crane, together with the cost of installing these, would be approximately $29,500.

It has been necessary to make some rather extensive improvements in certain sections of the present underground steam line, and in view of the fact that several large buildings are needed in the near future, the engineer deems it advisable to undertake these repairs and alterations, looking somewhat into the future. We are asking, therefore, for an appropriation of about $24,000 for initial improvements.

Market-garden Field Station.

For properly improving the land purchased for the market-garden field station, in accordance with the act of the Legislature, 1916, and for providing suitable equipment for the prosecution of experimental work in market gardening, an appropriation of $25,000 is requested. A sum of $10,000 is requested for labor and other maintenance costs for a two-year period ending Dec. 1, 1918.

REPORTS OF OTHER ADMINISTRATIVE OFFICERS.

IN THE DEPARTMENTS OF INSTRUCTION.

The Dean.

On account of a very large freshman class of 1915, the work of the dean's office accumulated considerably as the year came to a close. Our work has much to do with the freshmen, especially in respect to helping them pull through at the end of the academic year. The transition from the two-semester basis to the three-term basis also added a great deal to our office work, such as planning new record cards, forms, etc. Altogether it was a comparatively busy year.

During the year we introduced a "work and character record" of the students, and expect that it will prove helpful and effective as a permanent record, and fairly accurate. We asked each instructor to indicate on a record blank the intellectual, vocational and moral qualities revealed by each student in his class. We shall have an impression of the students recorded by each instructor each term on this blank. In this way we shall have at the end of four years a composite impression that may be a real aid to prospective employers, and to others who may make inquiries. It will also help us to tell the boy better than we now can what kind of work he might best take up.

With the beginning of this term we inaugurated a scheme of class advisers, — three over the freshman class, two over the sophomore class, and one each over the two upper classes. The duties of the advisers are to serve as an intermediary between the faculty and the class, to consider with the class sympathetically any questions such as the class wishes to have faculty advice upon, and to confer personally with individuals who are down in scholarship or who fail to have the proper attitude toward their work. The freshman advisers have been especially active during the term, and I think quite helpful. It is, however, too early to make a definite statement as to the results.

Our great need is for time and help to total, classify and interpret the records that we are accumulating. We cannot do this now with the present force. The increased correspondence and the three-term system have added so much to our duties that our half-time clerk cannot do any more than to carry the extra burden.

EDWARD M. LEWIS,
Dean.

The Division of Agriculture.

The work of the division has continued along lines previously determined upon and approved. The increased equipment afforded has given much needed facilities for work, and has been thoroughly appreciated by the staff and also by the student body, as shown by increased interest and registration. Among these facilities the Division Library in Stockbridge Hall, under the efficient care of the library assistant assigned to it, deserves mention.

Beginning in September, 1916, the Departments of Agronomy, Animal Husbandry and Poultry Husbandry have co-operated with the Department of Pomology in offering a required laboratory course in agriculture for freshmen.

The completion of the second unit of the rural engineering shop has enabled the department to offer courses in building construction and the repair of farm equipment. The completion of the third unit and the addition of an instructor in forge work are strongly recommended.

On the farm a small appropriation is needed for modern tools and machinery; as stated in a preceding report, a college farm should lead and not follow in the matter of its equipment. The Department of Animal Husbandry has submitted plans for a small calf barn. This building, in addition to its value as a demonstration, would add to both the ease of caring for and the profit from the college herd.

Among the important needs are: (1) Sufficient money for salaries, so that our best men may not be drawn away by other institutions. (2) A closer relation between those engaged in teaching and extension work and those engaged in research work. This has been accomplished in one of the departments

of the division, and the results justify the hope that the other departments may soon be similarly organized. Agriculture is a living, growing science, and efficient teaching demands close relations with research, probably not in the same person, but in the same department. (3) A more liberal administration of our entrance requirements. There is a grave question whether all students studying for an agricultural vocation, even if they are to become leaders in the rural communities, can afford the time now spent upon the study of French and German, or possibly even some of the higher mathematics. Not lower entrance requirements, but a broader view is needed if the agricultural vocations are to receive their greatest help from the college.

J. A. Foord,
Head of the Division.

The Division of Horticulture.

An important change in the activities of the division for this year comes with the establishment of a freshman course under the charge of Prof. John T. Wheeler. Another progressive step has been the wider development and intensification of the extension work in landscape gardening. Mr. F. A. C. Smith, who came to us about Feb. 1, 1916, has proved to be very energetic and efficient in this work. A large demand for this service has developed and some very interesting projects are under way in different parts of the State.

Probably the most important development in the division this year has been the acquisition of the Mount Toby demonstration forest tract. Of a somewhat similar nature is the acquisition of a tract of land in North Lexington, to be used as an cut-station of the Department of Market Gardening.

We greatly need to develop a Department of Horticultural Manufactures. This enterprise requires a small laboratory building and at least one good teacher. This project has been pending now for some years and grows constantly more desirable. With the acquisition of the out-station for the Department of Market Gardening it seems desirable to strengthen the organization of this department and to push with considerable vigor the work along these lines. For this purpose, and in the

interests of other branches in the division and the college, it is very desirable that a first-class teacher be employed to develop courses in plant breeding.

The Division of Horticulture is beginning to be seriously crowded for room. After much discussion it appears that the easiest and best relief would come through moving the Department of Landscape Gardening out of Wilder Hall. Various projects have been considered looking toward this end, especially the remodeling of the old Stockbridge house. At present it seems that the end could best be accomplished by the erection of a small building in the horticultural service group on the hill, this building to be of such a character that it could be converted to other uses sometime in the future. While such an enterprise would be comparatively inexpensive, it would give substantial relief to various branches in the Division of Horticulture, especially to the Departments of Pomology and Landscape Gardening.

F. A. Waugh,
Head of the Division.

The Division of Science.

In the Division of Science the year has found little in the way of changes. A few new courses have been offered, and with the division of the year into three terms, many adjustments have, of course, been necessary.

The increased number of students during the last few years has produced difficulties in the way of accommodation and equipment in some cases. The most recently established departments have been able from the start to anticipate something of the demand and provide more or less completely for it. Some of those longer in existence are housed in buildings probably amply large for the time when they were erected, but inadequate now, and their equipment also needs increasing to meet the needs of larger classes.

The general feeling of those connected with the division seems to have been that while many improvements are desired to strengthen the various departments, much can also be done with the opportunities available, and that the thing to do is to accomplish as much as possible under present facilities.

In the Department of Botany important changes in the organization have been made. The teaching has been reorganized, and a complete revision has been made of the course of study offered in this department. The year's work is starting on a new basis. The department has endeavored to secure better balance and closer co-ordination of the courses within the department and with the work of other departments. There are still some readjustments desirable. Perhaps one of the most important changes is that which gives students opportunity to pursue a full year's work in botany prior to the junior year, thus providing a much better basis for the elective courses which follow. A new elective course in systematic mycology, extending through three terms, will give a much better preparation for courses in phytopathology which follow. Division of the work of the junior course dealing with diseases of crops, giving opportunity for men majoring in technical lines to confine their study to the diseases of the particular crops which interest them, has increased the popularity and usefulness of this course. The course in plant physiology has been thoroughly revised and is proving a very valuable course, not only for the major students but for those specializing in such technical lines as greenhouse management and agronomy. Important changes in the conduct of graduate work have also been made. There is urgent need of some new equipment, especially modern microscopes to replace a considerable number of very old ones. There is also most urgent need of better accommodations for courses in plant physiology.

The Department of Chemistry has established a chemical seminar which meets once in two weeks, at which graduate students discuss their own work or review important lines of work published in the different chemical journals. The professors of the department also discuss special chemical topics, and take part in friendly criticism of the work brought forward by the graduate students. A larger number of students than usual are electing the various chemical courses. Thus in 1915, 50 students elected qualitative analysis, and in 1916, 70 students are electing the course; in 1915, 33 elected organic chemistry, and in 1916, 37; in 1915, 18 elected junior qualitative analysis, and in 1916, 25. It appears also that there is

more of a tendency than formerly for other departments to recommend students majoring with them to take chemistry as a minor. There remains the same pressing need, — a new laboratory. The department finds itself severely handicapped because of lack of small laboratories for graduate students. In connection with the new laboratory, a small glass house will be needed to conduct experiments in plant nutrition; also one or more lysimeters, for studying the action of different elements of fertility on different types of soil.

In the Department of Zoölogy a new elective course has been introduced in the sophomore year and a new required course in agricultural geology in the freshman year. The department has adjusted itself as well as possible to the four-term plan, and the work has gone forward much as in former years.

In the Department of Mathematics the most pressing need at this time is that some better provision be made for the care of the clerical work of the department.

The Department of Microbiology rejoices in having a home at last. When equipped in full, the department will be in excellent condition to meet the teaching requirements likely to be placed upon it.

The Department of Veterinary Science reports no new developments of special importance.

H. T. Fernald,
Chairman of the Division.

The Division of the Humanities.

The change to the three-term plan is likely to have some influence upon the courses elected in this division, although no good judgment can be formed of this influence until the plan has been in operation for at least two or three years. However, it is to be observed that this autumn there has been quite a notable reduction in the electives in certain courses, as in French; although in one case there has been a marked increase in the number of students taking German. It is probable that the larger elections in the Division of Rural Social Science may reduce the elections in this division.

I have emphasized in former reports the need of supporting public speaking in the college and will not renew the matter

now, except to say that we need a strong work of this kind, and every possible encouragement should be given to the man who tries to build up that branch of the humanities.

We have a number of problems. Perhaps the most serious is the instability of the location on the campus. There are many difficulties in conducting classes to advantage in buildings used by other departments for different purposes. We ought to have permanent headquarters for the division, with proper offices and classrooms, bringing together as much of the humanities' work as possible under one roof, where mutual interest may be developed and an atmosphere built up, which will, with continuous concentration, increase of equipment and the study of method, get all courses adapted to the needs and character of the student body and the goal of the college, and greatly advance the work of this division.

Another problem is, to what extent can our subjects be turned towards the agricultural vocational goal and the material used be brought in from that field? Or, shall the humanities be the one line of study which may disregard the vocational objects of the college and aim at general citizenship and culture of the broadest type? Another question that I should like to suggest is, should the language and literature be converted from the old three and two hour system to a more intensified plan of study, thus simplifying the schedule to that extent and making less conflicts with other subjects?

I would like to recommend a good general course in classics in English, and also point out the need of a system of prizes in humanistic subjects and debating.

R. J. Sprague,
Head of Division of the Humanities.

The Division of Rural Social Science.

The principal changes in the Department of Agricultural Education during the past year have been the elimination of administrative responsibility for boys' and girls' club work, the addition of two undergraduate courses, the increase of graduate students from one in the previous year to four in the current year, and a decrease in the facilities for doing the undergraduate work in the courses in methods of teaching. There has

been a pronounced increase in the demand for the State teacher's certificate. The requests for teachers continue to exceed the supply more than two to one. There has been a greatly increased demand for work in some courses that in previous years attracted no students whatever. Eleven students are now majoring in the department as against five last year. The instruction in all the courses, undergraduate and graduate, in this department and in one course in rural sociology is carried on by one person. The situation calls for relief at once.

During the past year a major has been established in the Department of Agricultural Economics, and already 19 students have registered for major work. The total enrollment in the department for the year was 317. Of these, 11 are graduate students doing either major or minor work. A new course has been given in transportation of agricultural products, dealing with the development of transportation in the United States; highways, waterways, railways and electric ways; the opening of new agricultural areas and industries. The department has prepared, in co-operation with the Federal Office of Markets, a bulletin on the cost of distributing milk in six cities and towns of the State. An abridged edition of this bulletin has been made for general circulation. The head of the department assisted in the preparation of the program of the graduate school of agriculture, which held its biennial session at the college in July. One section, giving four courses and one seminar, was devoted entirely to the discussion of problems of agricultural economics.

The courses offered by the Department of Rural Sociology have been reorganized to meet conditions arising under the three-term basis of college work, and the major in rural sociology was offered for the first time this year. The enrollment in the regular courses for the fall term was more than double that of the enrollment for the first semester of last year. The major has been elected by four men. The chief task of the department for the fall has been the selection and arrangement of material for the required course to be given sophomores in the spring; this work is now practically completed. The department is undertaking a series of studies in rural communities hav-

ing a large number of foreign-born residents. The first of these studies will have to do with conditions that affect the health of the communities and the improvement of these conditions through community co-operation and organization. There have been a number of calls from within and without the State for help along various lines. These calls have been for information for talks to boys' clubs and other organizations, etc. A course of lectures on types of rural communities and the community survey was given by the head of the department at Teachers College, Columbia University, this summer. This fall a series of evening lectures on community organization was given at the same institution. These lectures in no way interfered with the regular college work here.

KENYON L. BUTTERFIELD,
Head of the Division.

GENERAL DEPARTMENTS REPORTING TO THE PRESIDENT.

The Library.

The year just ended has been one of unusual activity. The total number of books accessioned is 4,517, the largest annual increase in the history of the library, making a total of 52,928 volumes. More students are making use of the main library and its branches in the department buildings because of increased assignments in connection with their courses of study, and also on account of our better book collections. More library extension work has also been carried on during the past year, — 39 libraries having received 679 books and 49 pamphlets through this phase of our work. During the past year we have issued library leaflets on the following subjects: books for teachers, poultrymen, high schools and farm women, and on soil fertility, garden design and garden making, and farm crops. This means that up to date we have published 23 library leaflets in editions varying from 1,000 to 3,000 copies of each, with a total printing of 32,000 copies.

Our need for a new library building should not be overlooked. Students and teachers become discouraged in the search for material when it becomes necessary to squirm through crowded aisles, climb ladders or resort to the collections stored in the

cellar. Visitors, upon looking over our equipment, express surprise at our large and valuable collections being exposed to fire and other dangers, and voice the economic loss of time and energy spent in working under our present conditions. Time flies so fast — so many men have come and gone without getting many of the best things which a good up-to-date library might have offered — that the real situation presented to our research workers, faculty, students and library staff becomes a very serious one indeed. Our earnest hope, for the benefit of the students and teachers who come to us and rightfully expect better working quarters, is that the next Legislature will offer relief in the form of a new library building, complete in all of its appointments, for the proper carrying on of all lines of library work.

CHARLES R. GREEN,
Librarian.

Military Department.

There has been a decided improvement in the various drills during the fall term over the work last year. This has been due to the following reasons: —

First. — The two additional military courses for cadet officers of the senior and junior classes has enabled me to see that the theoretical part of the outdoor work for each week was prepared and understood by the cadet officers who conducted this work.

Second. — Twenty-one students attended the United States training camps at Plattsburg, N. Y., and every captain and many first lieutenants are graduates of these camps.

Third. — The recent congressional legislation relative to the reserve officers training corps at colleges has had the effect of stimulating the interest in the military to a great extent.

At the present time the department work is handicapped by a drill hall that was built about thirty years ago, when the college had an enrollment of perhaps 150. It is entirely inadequate for the 400 students in the military department now. The armory and storage rooms are as inadequate as the hall.

H. W. FLEET,
Professor of Military Science and Tactics.

Department of Physical Education and Hygiene.

The work of the department has been conducted through the year along the following lines: —

1. Each student in the entering class was given a physical examination during the first month of the college year, thus reducing the possibility of any injury arising from ignorance. In the examination especial care was taken to detect any defects of the vital organs, sight and hearing. Each person is given a short talk following his examination concerning his condition, the kind of exercise he should have and the proper care of his body.

2. The freshman class was given a course of lectures and written quizzes on personal hygiene during the first term.

3. The physical director has immediate charge of health conditions in the college, seeing that cases of minor illness or injuries are cared for either by the resident nurse at the infirmary or by a member of the Department of Physical Education, the calling of a physician in cases where it seems necessary and sending those cases which need the attention of a nurse to the infirmary, and checking up on all illness and injury by granting the excuses required by the dean for those students who have been absent from classes because of either illness or injury. In matters of general health conditions the physical director is guided by the action of the college health committee and the advice of the Department of Microbiology.

4. During the winter months the department requires three hours of physical exercise per week for each member of the three lower classes. Those men who have been found by physical examination to be physically normal are permitted to elect one of the several athletic activities; those who have been found to be below normal physically are given individual instruction in so far as our present equipment will permit. Walking trips may be substituted for physical exercise in the gymnasium, and during the past year from 150 to 200 students have elected this form of exercise. The work of the indoor classes of from 30 to 40 men each consists of gymnastic exercises, — such games as basketball and indoor baseball.

The physical director is general manager of athletics, supervising arrangements for contests with other colleges, buying

supplies for the teams, assisting in the coaching, and having final control over players and games.

The interest in intercollegiate and intramural activities has been steadily growing. An accurate estimate of the participation in all sports during the year shows that in track about 75 men participated; cross country, 50; hockey, 75; baseball, 175; tennis, 25; football, 140; and basketball (other than required gymnasium), 40. After counting out duplications we find that approximately 50 per cent. of the student body voluntarily took part in some form of supervised athletic sport during the year.

The new athletic field is so far toward completion that the entire surface has been open to use this year. This has meant that many more opportunities for out-of-door recreation have been offered than it was ever possible to offer before. The fact that the running track is not completed is the greatest handicap now existing in the development of the general use of the total space. With the completion of the track I think it is very safe to say that the number of men participating in track athletics will be trebled.

The limited quarters in which the regular gymnasium work is to be carried on in the winter season make it impossible to do indoor gymnastics which can compare in any wise favorably with those of other colleges. From December 1 to April 1 the drill hall floor is in almost constant use from 8 o'clock in the morning until 9 o'clock at night.

The immediate pressing need of this department is a suitable gymnasium for the physical training of students during the winter months. Every student should receive gymnastic instruction and training of such a nature as to keep his physical education and development on a par with his mental development. Many of our students who should receive individual attention and treatment are neglected simply because the present building is too small, unsanitary and poorly equipped. A suitable gymnasium with a swimming pool is our greatest need.

The greatest problem of this department is to provide means for our students to follow out the exercises prescribed for them, and require those who are not themselves inclined to take exercise to take some form of systematic exercise at least three

times a week. With the completion of the athletic field our ideal of having every student take part in some form of active exercise may be realized for at least half the year, but during the winter months, when there is no military drill, and regular exercise is a necessity, we are confronted with the problem of finding forms of exercise which are possible with our present equipment.

CURRY S. HICKS,
Professor of Physical Education and Hygiene.

The Supervisor of Short Courses.

A. Winter Schools.

Twenty-two courses were offered in the ten weeks' winter courses. The enrollment was 153.

Farmers' week was seriously interfered with by one of the most severe storms of the winter, so that the attendance was about one-half what it should have been.

A bankers' conference was held at the college for the first time. An effort was made to create more interest on the part of bankers in agriculture in the State; the attendance was 28, and we believe the effort was very much worth while.

The tree wardens' school was discontinued.

The county agents' conference, the Polish farmers' day, the apple-packing school and the beekeepers' school were held as usual, with increased attendance and interest.

B. Summer Schools.

The summer school of agriculture and country life was held with an increase in attendance over previous years of approximately 25 per cent. A good deal of effort was made to arrange the summer school so that it would appeal to groups of workers such as club leaders, rural school teachers, etc., with good success. Some forty-five courses were offered.

The conference on rural organization, usually held as a closing feature of the summer school, was omitted last summer on account of conflicts with work arranged by the graduate school of agriculture. A small conference of the executive officers of the organizations which assist in the conference on rural organization was held in October. At this time plans centering in the

work of the Massachusetts Federation for Rural Progress were discussed, and I feel these will show very good results later on.

The college was honored last summer by having the sessions of the American Branch of the English Folk Song and Dance Society held on the campus. Not only did this school bring more than one hundred people in touch with the college, but it also gave those who live in this community an entirely new idea and conception of the place which such things as folk songs and dancing may properly occupy in recreation, especially of our small towns.

Recommendations.

I can but reiterate what I have said before, but in stronger terms, if possible, as to the desirability and necessity of placing the supervision of the short courses in the hands of some one who can give them his undivided attention. They have grown to the point where to handle them properly would require the full time of a supervisor.

The short courses need better financial support. Heads of departments are calling for more extra instructors, and since they are no longer considered as extension work, they should be supported from the regular college budget.

Some of the shorter courses, however, are so closely connected with the extension work that I feel the new supervisor should have some official relationship to the director of the extension service.

Many demands are coming from different sections of the State, and from various classes of people, to have the short course enlarged. I feel that these demands should be met at the earliest possible moment.

There seems to be need of short courses and extension courses of the following kinds and grades: —

A. Short courses of college grade.
   - For graduates of county agricultural schools.
   - For graduates of departments of agriculture in high schools.
   - For graduates of high schools not eligible to the four-year work.
   - For graduates of liberal arts colleges who desire special work in agriculture.
   - For persons over twenty-one years of age who are not prepared for regular four-year work.

B. Short courses of noncollege grade.
  One year special technical course, *i.e.*, fruit growing, poultry, etc.
  Continuation courses one year in length for graduates of county agricultural schools, or a department of agriculture in high school.
  Winter schools of twelve weeks.
  Summer schools of two, four, six or twelve weeks.

C. Courses in the nature of conferences or institutes one week or less (might be considered as extension work) such as —
  Farmers' week.
  Bankers' convention.
  Conference of superintendents of State institutions.
  Officers of farm bureaus.
  County agents' conferences.
  Conferences of fertilizer agents.
  Conferences of milk inspectors.
  Conferences of feed dealers.
  Conferences of seed dealers.
  Conferences of town officers.
  Conferences of tree wardens.
  Conferences of rural librarians.
  Conferences of grange officers.
  Conferences of judges at fairs.
  Meetings of rural clergymen.
  Meetings of county Y. M. C. A. workers.
  Meetings of county Y. W. C. A. workers.
  Officers of village improvement associations and for other groups that might be helped by the college.

It is the desire of the college to organize its short course work so that citizens of the State may have a chance to come to the college for help and assistance, be it for a period of three days, three months or for a year.

William D. Hurd,
Supervisor of Short Courses.

The Director of the Graduate School.

This autumn the enrollment in the graduate school is 57, as compared with 52 of a year ago. Of these, 18 registered for the degree of doctor of philosophy, 29 for the degree of master of science, 5 for the degree of master of agriculture, and 5 registered for no degree. These students come from a wide range of institutions and of territory. Probably we now have more students in the graduate school who were not undergraduates

at this college than we have of those who received their degree here. Last June 3 students received the degree of doctor of philosophy and 5 the degree of master of science.

Instruction.

Many of our best equipped instructors, who are capable of creative and valuable performance and also are needed in directing and suggesting for others who are beginners, are so burdened with routine duties and teaching that results of vital importance to agriculture are wanting. Daily routine grinding on the part of the instructors does not produce the best environment for undergraduate students, does not instill the right spirit into the graduate students who are destined to become the teachers, investigators and experts of the future, and does not contribute to the type of investigations which agriculture is now demanding. It is very much desired, therefore, that financial relief may come to alter this condition, for time, reflection and freedom for study and research are requisite to promote an agriculture which will be professionally on as high a plane as any other field of activity having science as its basis.

Degrees.

It is becoming more and more evident that the work of the institution falls into two broad divisions, one professional and the other scientific (broadly interpreted). Both of these, of course, are based upon the broad subjects which pertain to humanity and culture. These two grand divisions are respectively divided into several subdivisions or specialties. Experts of the most intensive training are demanded in each specialty. Graduate work or study and training are essential to the preparation of these experts, and recognition for this graduate work is measured by degrees.

In the scientific division, the higher degrees of master of science and doctor of philosophy have sufficed for all purposes. The professional division, however, from time to time calls for more definite designations in order that the degree will specify the particular usefulness of the individual. This institution recognized the growing demand of this professional division by establishing the degrees of master of agriculture and doctor of

agriculture, and recently the graduate staff recommended the establishment of the degree of master of landscape architecture. The multiplication of degrees is seemingly reprehensible, but so far has been the only solution of the difficulties. How far this practice of increasing the number of degrees in connection with well-defined specialization should go is a question which no one has the power to answer offhand. The future only can determine the wise course. However this may be, whenever a course stands out conspicuously and apart from other courses and has a peculiar and well-defined purpose, it may be justifiable to create a degree having as much significance as the course which it represents.

When this is considered in the light of the fact that here in the United States very nearly one hundred different degrees are granted, and also when we must admit that the degree is nothing more than a certificate of definite educational attainment and experience, we must then conclude that these peculiarly specific degrees have an economic and educational value.

General Required Course for Graduate Students.

In a technical institution there is a great tendency to place the limits of education within the circumscribed technical pursuits. Students fail to grasp the broader relations of life and to become appreciative of such thoughts and activities as contribute to its richness and fullness. In order to supply this real want in our educational system in this institution, especially for those whom we are training for experts in the graduate school, a course has been outlined which will extend over three years. The students meet once each week for this period.

This series of studies has been propitiously and satisfactorily initiated by Prof. W. J. Newlin of Amherst College, who has been treating "Ten Great Philosophies" during the first term.

The courses planned are as follows: —

Art.
Literature.
Philosophy.
Logic.
Social Movements.
Philosophy of Science.
Philosophy of Practices.

Facilities for Graduate Students.

It has become a recognized policy on the part of the agricultural colleges of the country to foster graduate work for those who are intending to pursue some phase of intensive agriculture, whether professionally or scientifically. It is an accepted belief by many, too, that it is very desirable to conduct this advanced work in an atmosphere surcharged with agriculture.

While realizing this to be a good policy, it becomes necessary to consider those facilities which will develop within the graduate students the best type of scholarship and the best results of research.

Some of the departments are having difficulty because of material accommodations. There seems to be a growing feeling on the part of several departments that graduate assistants, at least, should be accommodated with private quarters in order that they may carry on their investigations without constant interference from others. This is especially pertinent at the present time to the Departments of Botany, Chemistry and Entomology. They have tried out a common-room plan for graduate students and have found it unsatisfactory, and would now like such modifications as will correct and improve this feature. Laboratories have found that the best research can be done only in seclusion.

The Department of Chemistry, too, suffers from obsolete physical conditions. The present building is unfit for chemical work as well as extremely dangerous. Students must necessarily suffer from such crude facilities as are available, and especially from those which are lacking entirely. We trust that the time may come in the very near future when these requests may be made real by increased State allowances.

Charles E. Marshall,
Director.

The Director of the Experiment Station.

There have been few changes in major positions on the station staff during the year. The frequent loss of promising assistants has rather seriously interfered with progress in certain lines of work. This loss has been due in almost all cases

to the fact that the salaries which we can pay are less than those paid by the Federal government and by similar institutions for work of the same class, or because of the far larger salaries offered in commercial work.

There has been no change in general policy and but little in lines of work in the experiment station during the year. Most of the problems under investigation are fundamental and will require considerable periods of time for thorough study. This, it will be understood, does not mean that results of immediate value in their application to our agriculture are not being secured. Thus, for example, we are studying numerous manurial and fertilizer problems, and in every line new lanes of darkness are constantly disclosed; our results nevertheless enable us meanwhile to give valuable suggestions. Precisely the same situation exists in connection with our study of feeding problems. Indeed, in almost every investigation progress establishes new facts which have a direct bearing upon practice, but at the same time discloses new vistas of needed inquiry. Frequent change in general lines of investigation not only is unnecessary, it would be highly undesirable. The general experimental work now embraces investigations in the following principal lines of inquiry: soil tests with fertilizers with different crops in rotation; comparison of the different materials available as sources respectively of nitrogen, phosphoric acid, potash and lime for both field and garden crops, with a view to determining the ultimate effects of each on the composition of the soil, the micro-organisms it contains and its physical characteristics; comparisons of different systems of fertilizing mowings and orchards; trial of different manures and fertilizers for both tree and bush fruits; comparison of methods of applying manures and fertilizers; variety tests of garden and field crops and fruits; tests of different spray materials and methods of spraying; comparisons of methods of pruning and of cover crops in orchard management; tests of nursery stock from different sources and of different ages; trials of new crops; determinations of the digestibility of feedstuffs; methods of feeding for milk; systems of feeding and management of poultry for eggs; efforts to determine the value and best methods of use of anti hog-cholera serum; studies upon the

diagnosis and transmission of avian tuberculosis; co-operation with selected farmers in the trial of crops and systems of fertilizing them.

In addition, the station is working upon certain research problems involving more fundamental and more strictly scientific investigation, and requiring the approval of the director of the Federal Office of Experiment Stations. The following are among the more prominent investigations of this class: —

1. To determine the principles which should underlie practice in the use of fertilizers for the cranberry crop.

2. Work in plant breeding, in the endeavor to produce more rust-resistant types of asparagus. (In co-operation with the Bureau of Plant Industry, United States Department of Agriculture.)

3. The effect of food on the composition of milk and butter fat and on the consistency or body of butter.

4. Why insecticides burn foliage.

5. Effects of meteorological conditions on the development of plants and crops, both in health and disease.

6. Relation of light to burning from spraying with fungicides and insecticides.

7. Relation of light to burning of vegetation from miscible oils.

8. Study of interrelation of stock and scion in apples.

9. The economic importance of digger wasps in relation to agriculture.

10. The diagnosis of white diarrhœa in adult fowls.

11. A study of the presence and disappearance of organic matter in soils; its influence upon fertility.

12. A study of so-called "tobacco sickness."

The last two have been taken up during the past year; the others named have already engaged our attention for some time.

The fertilizer work with asparagus at the substation in Concord has been discontinued, and definite advice, based upon its results, is given in the twenty-eighth annual report. A second distribution in small lots of roots and seed of rust-resistant strains of asparagus developed in this station was made last spring. Reports both from the 1915 distribution and from that

of this year, as yet incomplete, are in general favorable; but the fact that neither year was one of abundant rust infestation has prevented what can be regarded as a severe and therefore thoroughly satisfactory test.

The research investigations of mosaic disease of tobacco, it is believed, have demonstrated the active causes and have accordingly made it possible to give advice which we are confident will prevent serious injury from this cause. Dr. Chapman who was engaged in these investigations has, therefore, been authorized to undertake the study of what now seems to be a much more serious obstacle to profitable tobacco growing, — the so-called tobacco sickness, — a trouble which has already rendered success with the crop impossible on a considerable acreage which a few years ago was giving fine crops. In this investigation he is to receive such co-operation from the chemists, bacteriologists and mycologists of the station as developments indicate to be desirable. It is anticipated that the tobacco growers of the valley will endeavor to procure in the next session of the Legislature an appropriation to at least in part support this work.

The participation of the experiment station in the work of the market garden substation promises to develop in many important ways. Little can be done, of course, until the market garden station is thoroughly established and funds have been provided for its maintenance.

During the past year the trustees have authorized the employment of an assistant chemist to work in animal nutrition problems, under the immediate oversight of Dr. J. B. Lindsey. The first work to be undertaken will be an investigation of questions connected with the feeding of horses. Accommodations for this work will be provided by extensive changes already nearly completed in the building formerly used as the station creamery. Mr. C. L. Beals, who has served as assistant in the Department of Chemistry since 1912, has been appointed to the new position, and this line of investigation will begin within a few weeks.

The Needs of the Station.

The Purchase of the Tillson Farm and the Provision of Buildings for Experimental Work. — The Tillson farm is leased on very reasonable terms and the lease still has six years to run. The agreement for lease provides that the college may purchase the farm at any time within the six years, and for a price which does not exceed its normal market value. The purchase can be consummated at so reasonable a price that to fail to complete the transaction would be very short-sighted business policy. In view, however, of the fact that the option still has six years to run, it might be thought that purchase in the near future is not urgent. The fact is, however, that but very little experimental work on this farm will be possible except at very great disadvantage previous to the provision of buildings to be used in connection with the work. It would self-evidently be more than questionable as a matter of business policy to erect buildings on the farm so long as any uncertainty exists as to the ultimate acquisition of the property. It has been found absolutely necessary to make a few changes and repairs in the small cottage and to reshingle the tobacco shed standing on the property. These changes and repairs have cost rather over $500. Before we can undertake much experimental work on the farm — and we have a considerable number of pressing problems the solution of which we should undertake there — we shall find it necessary to erect a barn; and a house for the superintendent should also be provided. For the purposes indicated, the estimated sums needed are as follows: —

Purchase price of farm (definite agreement),	$5,000
Dwelling house for superintendent,	4,000
Barn and outbuildings,	6,000
Total,	$15,000

Land for Experimental Work with Poultry. — The need for additional land for experimental work with poultry, several times referred to in earlier reports, yearly becomes more imperative. The problems of breeding upon which we are engaged necessitate the rearing of very large numbers of birds, and these

to serve the purpose in view must be vigorous and healthy. Such stock is practically assured if chicks from sound birds can be reared on fresh range, but can hardly be secured otherwise. Since the area now available for poultry work is so small that the provision of satisfactory range within its limits is impossible, the lease of additional land is the only alternative if the work is to be successfully prosecuted, — an alternative unsound for business reasons which have previously been stated, and involving other serious disadvantages, chief among which is distance from the poultry center of the institution. The needs of this important branch of our work will be met only when we are provided with a farm for experimental purposes of sufficient size to allow the necessary rotations in the use of its different parts to insure uncontaminated areas annually for rearing experimental stock. The head of the department believes — and in his estimate I coincide — that at least sixty acres will be required. The amount of money which will be needed to purchase the required amount of satisfactory land is at present a matter of great uncertainty, but I do not feel that it will be prudent to estimate it at less than $8,000.

The Tuxbury Land. — The Tuxbury property, now leased for orchard experiments, should be acquired by purchase in the near future. The reasons have been previously stated in some detail. Both sound business policy on the part of the State and such security of tenure as will insure against untimely interruption to the work require that this be done. The estimated cost is $12,000.

Orchard Trees for the Entomological Department. — For the research work of the Entomological Department on insecticides, it is essential that about one acre planted to fruit trees of different kinds be placed under its absolute control. Experience has indicated that only under such control is it possible to obtain results in the integrity of which absolute confidence can be placed. The nature of the investigation is such, and the number of visits for treatment and observation required is so great, that if possible a location near the headquarters of the department should be secured. It is hoped that this need can be met by assignment of orchard already planted and now the property of the institution.

Land for Tobacco Investigations. — Reference has been made in this report to the investigation of tobacco sickness which has recently been begun. In connection with this investigation a moderate amount of plot work will be essential; but since this in the nature of things must for the most part be located on land which is suffering from the trouble under investigation, and since work in a number of different localities will be desirable, it seems best to lease rather than to undertake to purchase the land needed in this investigation. The estimated cost for the year 1917 is $350.

Buildings and Equipment for Market-garden Work. — The necessity for buildings — most important being glass houses adapted to vegetable growing — and equipment for the market-garden work has been referred to. This need cannot be met out of the current resources of the station without such degree of curtailment in other directions as is clearly impracticable.

Additional Experimental Work with Poultry. — There is much demand for an increase in the amount of our experimental work with poultry, far greater than can be met with present resources. An annual grant of $2,000 for this purpose is much to be desired. It is believed and hoped that the poultry keepers of the State will endeavor to secure such an appropriation.

Increases in Station Staff. — If the station is to meet the constantly increasing demands upon it on the part of the public, a gradual increase in the station staff must be provided for. There is already decided pressure for experimental work in rural engineering, in floriculture and in forestry. This demand with our present resources cannot now be met, but the following increases in station staff are so urgently needed that an effort is to be made to provide for them out of current funds: namely, a curator and a field pathologist in the Department of Botany; a high-grade assistant in the Department of Entomology; one graduate assistant each in the Departments of Agricultural Economics and Microbiology; and a stenographer for six months in each year — from May 1 to November 1 — for the cranberry substation. The dates at which it is hoped the employment of each can be made effective, and the estimated annual salaries, are as follows: —

Curator, Department of Botany, from Dec. 1, 1916,	$900
Field pathologist, Department of Botany, from April 1, 1917,	1,200
Assistant, Department of Entomology, from July 1, 1917,	1,800
Graduate assistant, Department of Agricultural Economics, from July 1, 1917,	420
Graduate assistant, Department of Microbiology, from July 1, 1917,	420
Stenographer, cranberry substation, from May 1, 1917,	300

I feel that attention should be called in conclusion to the fact, which finds illustrations in this experiment station, that a high degree of fruitfulness in investigation is not often realized except with a corresponding degree of concentration. Of course, the individual talent and characteristics will always largely determine the result; but these being equal, one man devoting practically all of his time to investigation will accomplish several times more than two men devoting one-half time to that line of work and subject to constant interruptions. This matter has frequently been under discussion in the annual conventions of experiment station directors and workers, and it will not surprise those who know the laws of the human mind that the views just expressed meet general acceptance. It is my belief that the following statement of policy is sound and that our efforts should be increasingly directed toward its early realization.

The Station Staff.

1. It should be the policy of the station in its main lines of investigation to employ in the work men who shall give their entire time to such work. This does not mean that in some cases station men may not do some teaching or extension work, but such work should be restricted to narrow limits. Experience in all stations has shown that a man will be fruitful as an investigator only if his time is but very little taken up by calls upon him for service in other directions. The teaching expected of station men should at most occupy only a small proportion of their time, and as a rule should be confined to advanced work and for the most part to graduate students engaged in research under them. An investigator should not be subject to frequent calls for extension service. Such calls lessen efficiency in sta-

tion work to a degree altogether disproportionate to the apparent consumption of time.

2. The division of individual salaries between college and station should be avoided as far as possible. Those men who are recognized as primarily engaged in college work should be paid exclusively from college funds, and, on the other hand, those men engaged primarily in station work, even though they do some college or extension work, should be paid exclusively from station funds. They should be recognized as station men and should be responsible through the heads of their respective departments to the director of the station. Equity as between college and station on the financial side can be easily provided for on the general principles above stated.

In making the statement concerning the needed increases in the station staff, the gradual realization of this policy has been in mind, and full provision for these increases will be an important step toward its realization.

WILLIAM P. BROOKS,
Director.

The Director of the Extension Service.

In presenting this report I have not attempted, as in former years, to describe the work of the extension service, but confine the discussion to what seems to me to be some of the significant features of our work of the past year.

The extension work of the past year has not been characterized by expansion. Lack of funds prevented the starting of any new lines of work. I do not feel, however, that the work has stood still nor gone backward. The year has been rather one of opportunity to "take stock," and to organize the extension work in its relationships to other departments of the college and to other agencies throughout the State on a far better and more satisfactory basis than formerly. Our extension specialists have studied their fields more thoroughly, have considered their work in its relationship to rural development, and have organized their work with greater care than in the past. And so I feel that very great progress has been made toward developing a State-wide unified and harmonious system of extension teaching for the Commonwealth.

Some of the More Important Features of the Work during 1916.

Several significant features of the work seem to suggest themselves.

1. *County Agent Work.* — The year has been one of marked progress in the organization of farm bureaus. Three new organizations have been started. None have failed. Middlesex, Dukes and Nantucket are the only counties not organized. The first of these will incorporate an organization on December 16. The work in the farm bureaus has been placed on a written project basis, relationships are more clearly defined, farm bureau officers have a better idea of the purpose of their bureaus, the county agents know their field better and are restricting their efforts to fewer lines of work. A significant thing has been the growth of work for women in four counties. Two other counties are to place agents in the field soon.

2. *Junior Extension Work.* — The boys' and girls' club work continues to be our largest and perhaps most popular activity. The development of junior extension work under the wise direction of Mr. Farley will, I think, far surpass any of the work done in the past, although the enrollment may not be so large as in previous years.

There is need of securing the passage of a law giving aid to towns or districts to help maintain supervisors, for adequate follow-up work is in our judgment the thing most needed at present.

3. *Co-operation between the College and the State Board of Agriculture.* — I cannot help but feel that the efforts to bring the trustees of the college and the members of the Board of Agriculture together, in order that there might be a division of labor, a definition of the field each organization is to cover, and the fact that these two boards have met in the spirit already shown, is really one of the achievements of the year.

4. *Rural Organization.* — More progress has been made in organized movements in agriculture in the Commonwealth during the past year. Thirteen new co-operative organizations for buying and selling have been brought into existence; 30 are

now in successful operation. College men and county agents have been leaders in the movement to organize the milk producers. Our publication on "The Cost of Milk Production" and the advance copy of "The Cost of Milk Distribution" have been taken as the authority on which to discuss the situation by all parties concerned. Especial mention should be made here of the great piece of work which has been done by the county agents in organizing the milk producers of the State and in bringing about a better adjustment of the dairy situation during the past few weeks.

5. *Local Community Organization.* — A goodly portion of Professor Morgan's time the past year has gone into important service connected with the development committee and the Massachusetts Federation for Rural Progress. The local community organization work, therefore, has not been prosecuted with the same vigor as in the previous year. Neither has the proper amount of follow-up work been put on communities which had become partially organized. I doubt whether we can afford to neglect the community organization work.

6. *Committee on Publications.* — The committee on publications has been supervising the issuing of all our publications, and I feel that our extension publications are now being issued on a standard which will bear comparison with any others in this country.

7. *Finances.* — Notwithstanding that we have had so many calls for more work, the fact that we came through the year with a balance of $2,572.75, in addition to the reserve and emergency fund, is worth mentioning.

8. *University Extension for the Connecticut Valley.* — During the year this college has joined with Amherst, Smith, Mount Holyoke, the International Y. M. C. A. College, and the Northfield institutions in a co-operative movement to offer university extension work to the people of the Connecticut valley and adjacent towns. This is in accordance with plans suggested by the University Council of Massachusetts for State-wide extension work. A large and comprehensive announcement has been distributed. The University Extension Bureau of the State Board of Education has assigned an agent to organize the work. His headquarters are at this college.

9. *Relationships to the United States Department of Agriculture.* — Our relationships to the United States Department of Agriculture have been most friendly and satisfactory. The work which they have desired to do has generally been carried on in accordance with the general memorandum of understanding, and minor difficulties have been quite easily adjusted.

10. *National Dairy Show.* — The coming of the national dairy show to Springfield seemed to place a peculiar obligation on this college. Ten or more members of our faculty put in a large amount of time in helping to make the show a success. I estimate that we spent between $2,000 and $3,000 in time and money in the work that we did.

Comments on the Work.

There are many problems which we are facing now and will have to face in the immediate future.

Perhaps the most important of these is adequate financial support for extension work. During the past year the following amounts have been spent for extension work in this State: —

1. State funds (apportionment 1915–16),		$43,032 59
2. Smith-Lever funds,		12,930 75
3. United States Department of Agriculture co-operative demonstration funds,		17,026 00
4. Funds raised by county organizations: —		
(*a*) County funds,	$37,200 00	
(*b*) Funds raised from other sources,	28,900 00	
		66,100 00
Total,		$139,089 34

The above sums do not include the appropriation of $50,000 made to the State Board of Education for extension work, the amount spent by the Board of Agriculture in the educational work which it does, the money expended by the county schools of agriculture and vocational departments, nor the money being spent by commercial concerns and individuals.

I feel that in a short time all these agencies will be called to account, and that every effort should be made to hold our college extension work, and also that carried on by organiza-

tions with which we co-operate, to such lines as can be justified before any Legislature or commission.

There are problems of adjustment to be still worked out as between the college, the State Board of Education, the State Board of Agriculture and other organizations, but these things I believe to be only a matter of time.

The relationships between our extension specialists and the county agents comprise a question which is being solved, and in my judgment, as county agent work finds its level these relationships will be easily adjusted. In fact, this problem is working itself out. Unless every county organization in this State is to maintain a corps of specialists comparable in number to the extension service of the college, the problem seems to me to be a rather simple one.

In what has been said I would not convey the impression that the organization of extension work in this institution has been perfected. Much progress has been made in the past year. A complete reorganization of our work into divisions co-ordinate with county agent work and junior extension work, with the idea of really taking hold of the organization of rural problems, will perhaps be the next step. However, little can be done in this direction until there is some relief given to the extremely stringent financial condition in which we find ourselves placed. The college through its extension work will no doubt function more and more as an organizer and administrator of large State-wide movements designed to affect the rural life of the State.

This college should extend its efforts to prepare men for service in the extension work field. There no doubt will be a large call for assistant county agents in the future, and for various lines of work which may be carried on under the Smith-Lever act in other States.

In conclusion, I can but reiterate what I have said before, that at the present time extension work in Massachusetts is organized on a fairly satisfactory basis. The extension service within the college articulates with the other activities of the college and station. Harmonious relationships exist between the college, the United States Department of Agriculture, the other State organizations and the farm bureaus. Differences

in opinion as to what work should be done, and the best methods of organizing, are being worked out in a frank, friendly spirit.

The call is even stronger than a year ago for the development of several new lines of work and for the better support of lines already started. Among the extension specialists most needed are: —

A supervisor of "itinerant instruction" to organize extension schools, exhibits, lecture courses, etc.

An extension specialist to work with the other State institutions, as mentioned in previous reports.

More extension specialists in correspondence courses, poultry husbandry, fruit growing, farm management demonstrations and home economics.

More supervision in the junior extension work.

Additional extension specialists for agronomy, injurious insects and diseases, beekeeping, work with foreigners, and also as advisers to such organizations as the Homestead Commission and others.

Also considerable more clerical assistance.

The cost of maintaining this extra work would be from $40,000 to $50,000 in addition to what we are now receiving. The detailed estimates were made by me in the 1914 and 1915 reports.

It is to be hoped that the work of the past seven years will have proved its value, so that Legislatures in the not distant future will take care of these ever-growing demands for work which means developing the industries of the State.

I wish, as in former years, to mention and commend the spirit shown by the extension specialists and the untiring energy which they put into developing their work. As I look over the extension work of other colleges, I fail to find a corps of workers more devoted to their tasks or more loyal to their institutions than are the men and women who make up our staff.

William D. Hurd,
Director.

TABLES AND STATISTICS.

Table I. — *New Appointments.*

A. In the Academic Departments.

Position.	Name.	Institution from which graduated and Degrees.
Instructor in zoölogy,	Stanley C. Ball,	Ph.B., Sheffield Scientific School, 1911; Ph.D., Yale University, 1915.
Instructor in dairying,	Harry D. Drain,	B.Sc.Agr., Ohio State University, 1913.
Field agent,[1]	Charles H. Gould,	B.Sc., Massachusetts Agricultural College, 1916.
Assistant in agricultural economics,	Ralph P. Hotis,[2]	B.Sc., Massachusetts Agricultural College, 1915.
Instructor in botany,	George W. Martin,	Litt.B., Rutgers College, 1912; M.Sc., Rutgers College, 1915.
Assistant in rural sociology,[1]	Joseph Novitski,	Oshkosh, Wis., State Normal School.
Assistant professor of English,	Charles H. Patterson,	A.B., Tufts College, 1887; A.M., Tufts College, 1893.
Assistant in English,[1]	Philip W. Payne,	A.B., Amherst College, 1914.
Shop assistant, rural engineering,[1]	George F. Pushee,	- - -
Instructor in poultry husbandry,[1]	Everett H. Rucker,	B.Sc., University of Missouri, 1915; A.M., University of Missouri, 1916.
Instructor in agricultural economics,	Ralph M. Rutledge,	B.Sc., Oregon Agricultural College, 1914; M.Sc., University of Wisconsin, 1915.
Assistant professor of horticulture,[1]	John T. Wheeler,	B.Sc., University of Wisconsin, 1916.

B. In the Experiment Station.

Assistant chemist,	Windom A. Allen,	B.Sc., Tufts College, 1916.
Assistant in veterinary science,	John B. Lentz,	A.B., Franklin and Marshall College, 1908; V.M.D., University of Pennsylvania, 1914.
Assistant chemist,	John B. Smith,	B.Sc., Tufts College, 1916.

C. In the Extension Service.

Extension associate professor of agricultural economics.	Edward F. Damon,	B.Sc., Massachusetts Agricultural College, 1910.
Supervisor of junior extension,	George L. Farley,	B.Sc., Dartmouth College, 1898; M.Sc., Dartmouth College, 1903.
Extension instructor in pomology,	Austin D. Kilham,	A.B., Drury College, 1913; B.Sc. University of Missouri, 1914.
Extension instructor in civic improvement.	Frank A. C. Smith,	B.Sc., Cornell University, 1912; M.L.A., Harvard University, 1914.
Extension instructor in charge of pig club work.	Victor A. Rice,[3]	- - -
Extension instructor in charge of poultry club work.	Roswell W. Henninger,[4]	- - -

[1] New positions.
[2] Temporary employment from March to June.
[3] Services to begin Dec. 4, 1916.
[4] Services to begin Jan. 1, 1917.

TABLE I. — *New Appointments* — Concluded.

D. In the Clerical Staff.

Position.	Name.
Chief clerk, Extension Service,	Elbert L. Arnold.
Clerk, Division of Horticulture,	Eleanor Barker.
Clerk, president's office,	Evelyn Brewster.
Stenographer, Extension Service,[1]	Doris Clark.
Cataloguer, library,	Lalia M. Damon.
Inventory clerk, treasurer's office,[1]	Maude Chambers.
Assistant, Department of Physical Education,[1]	Llewelyn L. Derby.
Stenographer, Division of Agriculture,	Hazel Dewar.
Clerk, graduate school,	Marion F. Dondale.
Stenographer, Department of Dairying,[1]	Katherine L. Fenton.
Stenographer, office of the dean and registrar,[1]	Margaret T. Gaskell.
Clerk, Department of Agricultural Economics,	Laura M. Hager.
Clerk, Division of Agriculture,	Mary G. Hanifin.
Clerk, Extension Service,	Ethel L. Kennedy.
Stenographer, Department of Entomology,[1]	Helen A. Martin.
Stenographer, Extension Service,	Gladys Miner.
Clerk, Department of Botany,	Grace B. Nutting.
Stenographer, Extension Service,	Marion Pomeroy.
Assistant, library,	Vivian L. Roy.
Stenographer, Division of Horticulture,	Ethelyn Streeter.
Clerk, Extension Service,	Flora E. Torrey.
Assistant, library,	Ethel M. Turner.

[1] New positions.

TABLE II. — *Resignations.*

Position.	Name.
Instructor in dairying,	Harold E. Baldinger.
Instructor in zoölogy and geology,	Frank N. Blanchard.
Extension instructor in charge of boys' and girls' pig club work,	Eric N. Boland.[1]
Clerk, Division of Agriculture,	Frances C. Boynton.
Clerk, president's office,	Bertha A. Brockhaus.
First clerk, Extension Service,	Mabel R. Case.
Cataloguer, library,	Ada M. Chandler.

[1] Takes effect Dec. 2, 1916.

Table II. — *Resignations* — Concluded.

Position.	Name.
Stenographer, Extension Service,	Phyllis J. Cogswell.
Clerk, Department of Botany,	Jessie V. Crocker.
Assistant chemist, experiment station,	Charles W. Davis.
First Clerk, Division of Agriculture,	Alice M. Gilbert.
Clerk, Extension Service,	Hannah M. Griffin.
Professor of agronomy,	Sidney B. Haskell.
Assistant in agricultural economics,	Ralph P. Hotis.
Clerk, graduate school,	Esther L. Houghton.
Extension professor of agricultural education,	Orion A. Morton.
Assistant in veterinary science, experiment station,	Beryl H. Paige.
Stenographer, Extension Service,	Marion Pomeroy.
Assistant in agricultural economics,	Frederick W. Read.
Extension instructor in pomology,	Ralph W. Rees.
Assistant chemist, experiment station,	Rudolph W. Ruprecht.
Clerk, Division of Horticulture,	Gladys E. Russell.
Stenographer, Extension Service,	Elsa Slattery.
Clerk, Department of Floriculture,	Dorothy F. Smith.
Assistant professor of English,	Henry E. Smith.
Assistant in botany,	Raymond G. Smith.
Professor of botany,	George E. Stone.
Assistant in veterinary science, experiment station,	Arnold P. Sturtevant.

Table III. — *Change in Title of Officers of the Institution.*

Name.	Former Title.	Present Title.
Ernest Anderson,	Associate professor of general and physical chemistry.	Professor of general and physical chemistry.
Paul J. Anderson,	Assistant professor of botany,	Associate professor of botany and associate plant pathologist.
Thomas Butterworth,	Assistant engineer,	Engineer.
George H. Chapman,	Assistant botanist,	Research physiologist.
Orton L. Clark,	Assistant botanist, experiment station.	Assistant professor of botany and assistant plant physiologist.
Harold M. Gore,	Assistant in physical education,	Instructor in physical education.
Marion Guertin,	Stenographer, section of beekeeping.	Clerk, section of beekeeping.
Burt A. Hazeltine,	Assistant in mathematics,	Instructor in mathematics.
Curry S. Hicks,	Associate professor of physical education and hygiene.	Professor of physical education and hygiene.
Arao Itano,	Assistant in microbiology,	Instructor in microbiology.

Table III. — *Change in Title of Officers of the Institution* — Concluded.

Name.	Former Title.	Present Title.
A. Vincent Osmun,	Associate professor of botany,	Professor of botany and botanist.
Sumner R. Parker,	Assistant State leader and extension professor of rural organization.	Extension professor of rural organization and county agent leader.
Loyal F. Payne,	Instructor in poultry husbandry,	Assistant professor of poultry husbandry.
Charles A. Peters,	Associate professor of inorganic and soil chemistry.	Professor of inorganic and soil chemistry.
Aurelia Wentworth,	Stenographer, Division of Agriculture.	First clerk, Division of Agriculture.

Table IV. — *Speakers for the Year.*

A. Speakers at Wednesday Assembly for Year ending Nov. 30, 1916.

1915.

Dec. 1. — President Kenyon L. Butterfield.
Dec. 8. — Student forum.
Dec. 15. — Hon. Elmer A. Stevens, Boston, Mass.

1916.

Jan. 5. — Prof. John Phelan, M. A. C.
Jan. 12. — Hon. Francis Neilson, M. P., England.
Jan. 19. — Mr. Francis B. Sayre, Williamstown, Mass.
Jan. 26. — Mr. Jerome Kidder and colored quartet from Hampton Institute, Va.
Feb. 9. — Student forum.
Feb. 16. — Mr. Raymond Robins, Chicago, Ill.
Feb. 23. — Dr. W. H. Jordan, Geneva, N. Y.
Mar. 1. — Mr. Lucius Wilson, Springfield, Mass.
Mar. 8. — Prof. Robert J. Sprague, M. A. C.
Mar. 15. — Prof. Alva Agee, New Brunswick, N. J.
Mar. 22. — President J. H. F. Main, Grinnell College, Iowa.
Apr. 5. — President Kenyon L. Butterfield.
Apr. 12. — Mr. Clarence P. Shedd, Boston, Mass.
Apr. 26. — Mr. Harry W. Kimball, Boston, Mass.
May 3. — Hon. James Wilson, Iowa.
May 10. — Judge Michael J. Murray, Boston, Mass.
May 17. — Prof. Talcott Williams, Columbia University, New York City.
May 24. — Hon. John Hays Hammond, New York City.
May 31. — President Kenyon L. Butterfield.
June 7. — Student forum.
Sept. 27. — President Kenyon L. Butterfield.
Oct. 4. — Dean Edward M. Lewis, M. A. C.
Oct. 11. — President Kenyon L. Butterfield.
Oct. 18. — Mr. Fred B. Freeman, New York City.
Oct. 25. — Mr. George W. Coleman, Boston, Mass.
Nov. 1. — Student forum.
Nov. 8. — Mr. Henry H. White, Amherst, Mass.
Nov. 15. — Dean William M. Warren, Boston University, Boston, Mass.
Nov. 22. — Hon. Samuel J. Elder, Boston, Mass.

TABLE IV. — *Speakers for the Year* — Concluded.

B. Speakers at Sunday Chapel for Year ending Nov. 30, 1916.

1915.

Dec. 5. — Rev. J. Stanley Durkee, Campello, Mass.
Dec. 12. — Prof. Walter Rauschenbusch, Rochester, N. Y.

1916.

Jan. 9. — Dr. Hubert C. Herring, Boston, Mass.
Jan. 16. — Rev. Rockwell H. Potter, Hartford, Conn.
Jan. 23. — Rev. Roger S. Forbes, Dorchester, Mass.
Jan. 30. — Rev. Frank W. Merrick, Danvers, Mass.
Feb. 13. — Rev. E. A. E. Palmquist, Cambridge, Mass.
Feb. 20. — Rev. H. Stiles Bradley, Worcester, Mass.
Feb. 27. — Prof. Benjamin T. Marshall, Dartmouth College, Hanover, N. H.
Mar. 5. — Rev. E. F. Sanderson, Brooklyn, N. Y.
Mar. 12. — Rev. J. Herman Randall, New York City.
Mar. 19. — Dr. Cornelius H. Patton, Boston, Mass.
Apr. 9. — Rev. Christian F. Reisner, New York City.
Apr. 16. — Rev. J. Ross Stevenson, Princeton, N. J.
Apr. 23. — Dr. Lee W. Beattie, New York City.
Apr. 30. — Rev. A. P. Reccord, Springfield, Mass.
Oct. 1. — President Kenyon L. Butterfield.
Nov. 12. — Dr. Richard C. Hughes, Madison, Wis.
Nov. 19. — Rev. Clarence J. Hawkins, Jamaica Plain, Mass.
Nov. 26. — Mr. Fred B. Smith, New York City.

TABLE V. — *Attendance.*

A. In Work of College Grade.

	Registration Nov. 30, 1915.	Registration Nov. 30, 1916.
Senior class,	108	104
Junior class,	110	138
Sophomore class,	162	174
Freshman class,	211	170
	591	586
Graduate students,	52	57
Unclassified students,	25	29
Vocational poultry students,	–	8
	668	680

B. Short-Course Enrollment and Convention Registration.

	1915.	1916.
Winter school,	182	153
Farmers' week,	–	980
Beekeepers' school,	–	10
Polish farmers' day,	–	220
Apple-packing school,	19	8
County agents' conference,	38	55
Bankers' conference,	–	28
Summer school of agriculture and country life,	162	170
Conference on rural community planning,	261	–
Conference on rural organization,	–	38
School for rural social service,	14	35
Poultry convention,	600	268
School for library workers,	25	–
Boys' camps,	92	88
Girls' camps,	13	27
	1,406	2,080

TABLE VI. — *Legislative Budget, 1916.*

Items.	Amount asked.	Amount granted.
Completion of power plant,	$35,000	$4,200
Library and equipment,	230,000	–
Rural engineering shops,	12,000	12,000
Student dormitory,	40,000	–
Miscellaneous improvements and new equipment,	60,000	20,000
Extra labor, Saturday half-holiday,	5,000	–
Mount Toby forest tract,	30,000	30,000
	$412,000	$66,200

TABLE VII. — *Statistics of Freshmen entering Massachusetts Agricultural College, September, 1916.*

A. Home Addresses of Students (classified by Towns and Cities).

Acushnet,	1	Holden,	1	Royalston,	1
Albany, N. Y.,	1	Holyoke,	2	Rutherford, N. J.,	1
Amherst,	10	Hopedale,	1	San Antonio, Tex.,	1
Arlington,	3	Jefferson Valley, N. Y.,	1	Sandwich,	2
Atlantic,	1	Kingston,	1	Sandy Hook, Conn.,	1
Belchertown,	2	Lancaster,	1	Santo Domingo,	1
Bolton,	1	Lawrence,	1	Shelburne,	1
Boston,	10	Lee,	1	Sherborn,	1
Boylston,	1	Leicester,	1	Shrewsbury,	1
Braintree,	1	Leominster,	1	Somerset,	1
Bridgewater,	1	Lowell,	3	Somerville,	3
Brockton,	2	Lunenburg,	1	Springfield,	5
Buckland,	1	Lynn,	1	Stamford, Conn.,	1
Byfield,	1	Malden,	3	Sunderland,	1
Canton,	1	Manchester,	1	Syracuse, Ind.,	1
Canton, China,	1	Marlborough,	2	Taunton,	3
Clinton,	1	Maynard,	2	Waban,	1
Dana,	1	Melrose,	4	Walpole,	1
Dighton,	1	Milford,	1	Waltham,	1
Easthampton,	1	Millbury,	1	Wareham,	1
Easton,	1	Millville, N. J.,	1	Warren,	1
Egypt,	1	Montvale, N. J.,	1	Warwick, R. I.,	1
Fall River,	1	Newburyport,	2	Waverley,	1
Farmington, Conn.,	1	Newport, R. I.,	1	Wellesley,	2
Florence,	1	Newton,	3	West Bridgewater,	1
Framingham,	5	New York City, N. Y.,	1	West Springfield,	1
Gardner,	1	North Adams,	1	Whitinsville,	1
Gleasondale,	1	Norwell,	1	Whitman,	1
Grafton,	1	Old Westbury, L. I., N. Y.,	1	Williamsburg,	1
Great Barrington,	6	Peabody,	1	Williamstown,	2
Greenwich, Conn.,	1	Pittsfield,	4	Winchester,	3
Groton,	1	Plainville,	1	Winthrop,	1
Hardwick,	1	Port Chester, N. Y.,	1	Wollaston,	3
Harrisville, R. I.,	1	Portland, Me.,	1	Woods Hole,	1
Hartford, Conn.,	1	Raynham Centre,	1	Worcester,	2
Haverhill,	1	Reading,	1		

TABLE VII. — *Statistics of Freshmen, etc.* — Continued.

B. Home Addresses (classified by States).

	Number.	Per Cent.		Number.	Per Cent.
China,	1	.59	New York,	5	2.94
Connecticut,	5	2.94	Rhode Island,	3	1.76
Indiana,	1	.59	Santo Domingo,	1	.59
Maine,	1	.59	Texas,	1	.59
Massachusetts,	149	87.65		170	100.00
New Jersey,	3	1.76			

C. Home Addresses (classified by Counties of Massachusetts).

	Number.	Per Cent.		Number.	Per Cent.
Barnstable,	3	2.01	Middlesex,	38	25.50
Berkshire,	14	9.40	Norfolk,	9	6.04
Bristol,	9	6.04	Plymouth,	9	6.04
Essex,	8	5.37	Suffolk,	12	8.05
Franklin,	3	2.01	Worcester,	21	14.09
Hampden,	8	5.37		149	99.99
Hampshire,	15	10.07			

D. Nativity of Parents.

	Number.	Per Cent.
Neither parent foreign born,	124	72.94
Both parents foreign born,	33	19.41
Father (only) foreign born,	7	4.12
Mother (only) foreign born,	6	3.53
	170	100.00

E. Education of Father.

	Number.	Per Cent.
Common school,	83	48.82
High school,	41	24.12
Business school,	13	7.65
College or university,	28	16.47
No statistics,	5	2.94
	170	100.00

TABLE VII. — *Statistics of Freshmen, etc.* — Continued.

F. Religious Census.

	Membership.		Preference.		Totals.	
	Number.	Per Cent.	Number.	Per Cent.	Number.	Per Cent.
Baptist,	13	7.65	8	4.71	21	12.35
Catholic,	14	8.24	–	–	14	8.24
Congregationalist,	46	27.06	31	18.24	77	45.29
Episcopal,	13	7.65	–	–	13	7.65
Hebrew,	4	2.35	3	1.77	7	4.12
Methodist,	10	5.88	5	2.94	15	8.82
Presbyterian,	3	1.77	1	.59	4	2.35
Unitarian,	3	1.77	1	.59	4	2.35
Universalist,	1	.59	3	1.77	4	2.35
Miscellaneous,	3	1.77	4	2.35	7	4.12
No statistics,	–	–	–	–	4	2.35
	110	64.73	56	32.96	170	99.99

G. Occupation of Father.

	Number.	Per Cent.
Agriculture and horticulture,	34	20.00
Artisans,	45	26.47
Business,	41	24.12
Deceased, or no statistics,	13	7.65
Miscellaneous,	11	6.47
Professional,	23	13.53
Retired,	3	1.77
	170	100.01

H. Intended Vocation of Student.

	Number.	Per Cent.
Agriculture or horticulture (practical),	62	36.47
Agriculture or horticulture (professional),	70	41.18
Miscellaneous,	–	–
Professions,	4	2.35
Undecided or no statistics,	34	20.00
	170	100.00

Table VII. — *Statistics of Freshmen, etc.* — Concluded.

I. Farm Experience.

	Number.	Per Cent.
Brought up on a farm,	53	31.18
Not brought up on a farm and having had no or practically no farm experience.	51	30.00
Not brought up on a farm but having had some farm experience.	66	38.82
	170	100.00

J. Miscellaneous Statistics.

Average age,	19.16 years
Number signifying their intention to seek student labor,	94 (55.30 per cent.)
Number boarding at the college dining hall,	117 (68.82 per cent.)

Table VIII. — *Entrance Statistics of Freshman Class.*

Number of applications (preliminary applications number 54),			352
Admitted,		202	
Matriculated,	170		
Failed to report,	32		
Rejected,		150	
Total,			352
Matriculated on certificate,			74
Matriculated on examination,			14
Matriculated on certificate and examination,			69
Matriculated on credentials from another college,			5
Re-entered,			8
			170
Matriculated without condition,			108
Matriculated with condition,			62
			170

Table IX. — *Cases treated at the Infirmary, Dec. 1, 1915, to Nov. 30, 1916.*

	Daily Count.	Individual Count.
December 1, 1915, to January 1, 1916: —		
House cases,	62	15
Out-patients,	26	25
January 1 to February 1: —		
House cases,	82	17
Out-patients,	50	28
February 1 to March 1: —		
House cases,	52	12
Out-patients,	38	17

Table IX. — *Cases treated at the Infirmary, Dec. 1, 1915, to Nov. 30, 1916* — Concluded.

	Daily Count.	Individual Count.
March 1 to April 1: —		
House cases,	10	4
Out-patients,	71	24
April 1 to May 1: —		
House cases,	6	2
Out-patients,	85	27
May 1 to June 1: —		
House cases,	26	10
Out-patients,	63	33
June 1 to June 19: —		
House cases,	29	8
Out-patients,	23	15
September 16 to October 1: —		
House cases,	–	–
Out-patients,	13	13
October 1 to November 1: —		
House cases,	22	7
Out-patients,	129	63
November 1 to December 1: —		
House cases,	35	9
Out-patients,	70	29

Number of house cases,	324
Number of out-patients,	568
Total,	892
Number cared for in the house,	84
Number cared for as out-patients,	274
Total,	358

Report of the Treasurer

For the Fiscal Year ending Nov. 30, 1916.

Balance Sheet.

		Dr.	Cr.
1915.			
Dec. 1.	To balance on hand,	$53,139 07	
1916.			
Nov. 30.	To receipts for fiscal year,	657,679 74	
	Expenditures for fiscal year,		$668,964 27
	Balance on hand,		41,854 54
		$710,818 81	$710,818 81

Schedule A. — Income.

		Items.	Totals.
Income from students and others,		. . .	$94,075 29
Tuition,		$3,200 00	
Laboratory fees,		5,718 75	
Rents,		5,521 51	
Department sales,		48,190 34	
Department transfers,		20,095 43	
Miscellaneous,		11,349 26	
Income from grants by nation and State: —			
State aid,		. . .	441,756 50
Income from endowment,		$3,313 32	
Appropriation for current expenses,		245,000 00	
Administration,	$32,000 00		
Maintenance,	105,000 00		
Instruction,	100,000 00		
Graduate School,	3,000 00		
Additional land,	5,000 00		
Appropriation for extension service,		50,000 00	
Appropriation for experiment station,		36,000 00	
Maintenance,	$30,000 00		
Feed law,	6,000 00		
Receipts from special appropriation,		107,443 18	
Federal aid,		. . .	84,785 23
Income from land grant of 1862,		$7,300 00	
Income from Hatch fund of 1887,		15,000 00	
Income from Adams fund of 1906,		15,000 00	
Income from Morrill fund of 1890,		16,666 66	
Income from Nelson fund of 1907,		16,666 67	
Income from Smith-Lever fund of 1914,		14,151 90	
Income from other sources: —			
Income from experiment station,		. . .	31,400 70
Fertilizer receipts,		$9,400 00	
Agricultural receipts,		5,080 69	
Cranberry receipts,		2,771 12	
Chemical receipts,		12,002 98	
Miscellaneous receipts,		2,145 91	

SCHEDULE A. — INCOME — *Concluded.*

	Items.	Totals.
Income from other sources — *concluded.*		
Income from extension service,	. . .	$5,662 02
Winter school,	$979 90	
Summer school,	1,825 88	
Correspondence courses receipts,	696 96	
Exhibits,	525 00	
Civic improvements,	986 11	
Miscellaneous receipts,	648 17	
Total,	$657,679 74	$657,679 74

Classification of Income from Students and Others.

	Laboratory Fees.	Department Sales.	Transfers.	Rent.	Miscellaneous.	Tuition.	Totals.
Agricultural economics,	-	-	-	-	$21 00	-	$21 00
Agricultural education,	-	-	-	-	70 00	-	70 00
Agronomy,	$137 75	-	-	-	-	-	137 75
Animal husbandry,	280 50	$0 38	-	-	-	-	280 88
Beekeeping,	-	288 05	-	-	-	-	288 05
Botany,	1,073 50	50 45	-	-	-	-	1,123 95
Chemistry,	2,506 75	44 41	-	-	-	-	2,551 16
Dairy,	101 00	11,131 41	$9,445 76	-	-	-	20,678 17
Entomology,	78 00	13 26	-	-	-	-	91 26
Farm administration,	-	1 50	100 55	-	-	-	102 05
Floriculture,	55 75	3,433 04	19 14	-	9 12	-	3,517 05
Farm,	-	28,146 91	840 02	-	-	-	28,986 93
Forestry,	10 50	-	-	-	-	-	10 50
General agriculture,	-	-	24 09	-	100 55	-	124 64
General horticulture,	-	2 50	3,827 67	-	237 12	-	4,067 29
Graduate school,	-	2 00	-	-	-	-	2 00
Grounds,	-	-	-	-	25 32	-	25 32
Hospital,	-	-	-	-	25 73	-	25 73
Improvements, 1916,	-	-	-	-	670 06	-	670 06
Landscape gardening,	242 00	12 92	-	-	-	-	254 92

Language and literature,	46 25	-	-	-	-	-	46 25
Library,	-	540 46	-	-	-	-	540 46
Market gardening,	18 50	1,730 37	396 07	-	-	-	2,144 94
Mathematics,	65 00	-	-	-	-	-	65 00
Microbiology,	331 25	-	-	-	115 68	-	446 93
Miscellaneous,	-	-	-	-	2,881 15	-	2,881 15
Military,	-	-	-	-	44 23	-	44 23
Physics,	6 00	-	-	-	8 96	-	14 96
Pomology,	100 50	1,336 31	215 24	-	-	-	1,652 05
Physical education,	-	-	-	-	98 50	-	98 50
Poultry husbandry,	105 50	1,329 64	4,926 89	-	108 38	-	6,470 41
Rural engineering,	111 00	104 23	-	-	-	-	215 23
Rural sociology,	-	-	-	-	1 59	-	1 59
Veterinary,	-	22 32	-	-	-	-	22 32
Zoölogy and geology,	449 00	18	-	-	-	-	449 18
Operating and maintenance,	-	-	300 00	-	6,893 99	$3,200 00	10,393 99
North dormitory,	-	-	-	$1,853 00	-	-	1,853 00
South dormitory,	-	-	-	2,171 80	-	-	2,171 80
College residences,	-	-	-	659 30	-	-	659 30
Executive order,	-	-	-	-	37 88	-	37 88
Draper hall,	-	-	-	837 41	-	-	837 41
Totals,	$5,718 75	$48,190 34	$20,095 43	$5,521 51	$11,349 26	$3,200 00	$94,075 29

Schedule B. — Expenditures for Fiscal Year.

	Items.	Totals.
College expenses, . . .	. . .	$394,683 19
Administration, . . .	$34,729 71	
Maintenance, . . .	215,409 87	
Instruction, . . .	144,543 61	
Experiment station, . . .	. . .	96,954 59
Administration, . . .	$1,029 25	
Feed inspection, . . .	5,632 53	
Fertilizer law, . . .	11,434 88	
Salaries, . . .	42,986 41	
Department, . . .	35,871 52	
Extension service, . . .	. . .	69,883 31
Salaries, . . .	$38,546 56	
Travel, . . .	10,291 70	
Departments, . . .	21,045 05	
Special appropriation, . . .	. . .	107,443 18
1914, agriculture building, . . .	$16,109 87	
Microbiology building, . . .	47,935 38	
Improvements and equipment, . . .	17,336 77	
1916, agriculture building, . . .	12,243 49	
Retaining wall and platform, . . .	4,200 00	
Rural engineering shop, . . .	9,617 67	
Total, . . .	. . .	$668,964 27

Analysis of College Expenditures.

Administration.	Office Expense.	Salaries and Labor.	Travel.	Minor Equipment.	Building Supplies.	Publicity and Lectures.	Student Activity.	Commencement.	Miscellaneous.	Totals.
Dean's office,	$241 00	$280 06	-	$8 72	-	-	-	-	-	$529 78
Executive order,	-	-	$2,335 99	-	-	$1,474 64	$1,092 68	$537 30	$2,981 16	8,421 77
President's office,	756 77	124 63	128 83	-	$8 06	-	-	-	89 22	1,107 51
Registrar's office,	435 67	100 54	42 71	-	-	-	-	-	-	578 92
Treasurer's office,	365 32	309 64	143 84	101 51	7 68	-	-	-	142 77	1,070 76
Administration (salaries),	-	23,020 97	-	-	-	-	-	-	-	23,020 97
Totals,	$1,798 76	$23,835 84	$2,651 37	$110 23	$15 74	$1,474 64	$1,092 68	$537 30	$3,213 15	$34,729 71

Maintenance.	Office Supplies.	Labor.	Laboratory Supplies.	Refunds.	Minor Equipment.	Building Supplies.	Travel.	General Expense.	Miscellaneous.	Salaries.	Totals.
Academic maintenance: —											
Agriculture,	-	$1,151 76	-	-	$194 60	$240 20	-	-	$23 58	-	$1,610 14
Agricultural economics,	$143 97	9 63	$50 52	-	15 79	-	$8 37	-	-	-	228 28
Agricultural education,	213 57	56 77	75 47	-	55 20	-	30 61	-	61 65	-	493 27
Agronomy,	68 51	204 43	269 24	$74 65	64 11	-	57 75	-	-	-	738 69
Animal husbandry,	90 93	109 10	59 82	10 50	8 96	-	119 20	-	-	-	398 51
Beekeeping,	115 75	1,058 19	131 45	-	238 09	121 17	17 71	-	-	-	1,682 36
Botany,	149 29	627 97	599 51	48 50	26 62	12 75	25 42	-	-	-	1,490 06
Chemistry,	184 47	1,138 23	2,938 26	681 07	16 64	55 37	5 74	-	-	-	5,019 78
Dairying,	150 09	2,538 85	21,052 70	8 94	921 28	71 44	101 94	-	-	-	24,845 24
Economics and sociology,	22 97	15	6 42	-	8 07	-	2 00	-	-	-	39 61
Entomology,	47 21	301 70	147 99	2 50	45 69	67 28	3 38	-	-	-	615 75
Farm administration,	126 05	25 93	56 28	-	49 60	-	36 43	-	100 55	-	394 84
Floriculture,	132 84	4,483 56	1,392 49	1 50	96 56	72 82	140 78	-	-	-	6,320 55
Forestry,	24 38	75 26	53 46	-	85 40	-	75 98	-	-	-	314 48
History and government,	1 40	-	-	-	-	-	-	-	-	-	1 40

ANALYSIS OF COLLEGE EXPENDITURES — *Concluded.*

MAINTENANCE.	Office Supplies.	Labor.	Laboratory Supplies.	Refunds.	Minor Equipment.	Building Supplies.	Travel.	General Expense.	Miscellaneous.	Salaries.	Totals.
Hospital,	–	$943 76	–	–	$65 00	–	–	$200 30	–	–	$1,209 06
Landscape gardening,	$12 73	8 02	$268 24	$26 35	62 23	–	$11 37	–	–	–	388 94
Language and literature,	24 96	133 11	91 87	16 32	102 60	–	–	–	–	–	368 86
Market gardening,	71 09	2,504 47	800 26	2 00	81 21	$3 06	158 26	–	–	–	3,620 35
Mathematics,	59 75	78 95	34 85	5 00	–	25 82	–	–	–	–	204 37
Microbiology,	94 95	254 78	375 11	137 64	105 65	41 91	3 95	–	$163 82	–	1,177 81
Military science,	157 47	892 82	2 67	–	275 16	10 04	7 50	–	252 92	–	1,598 58
Physical education,	155 91	135 30	292 58	–	80 14	32 62	324 41	–	–	–	1,020 96
Physics,	62 80	333 75	111 90	5 00	127 71	15 47	3 17	–	–	–	659 80
Pomology,	92 05	2,416 62	816 40	50	36 14	11 59	38 49	–	–	–	3,411 79
Poultry husbandry,	535 85	2,397 29	5,938 33	1 50	336 98	154 31	39 15	–	–	–	9,403 41
Rural engineering,	19 71	141 16	289 73	10 00	121 63	–	77 84	–	–	–	660 07
Rural sociology,	69 40	28 19	20	–	2 46	–	29 74	–	–	–	129 99
Veterinary science,	55 00	302 15	796 59	–	1 70	161 09	23 07	–	–	–	1,339 60
Zoölogy and geology,	29 71	182 75	209 01	27 50	55 89	–	50 31	–	–	–	555 17
General maintenance: —											
Equipment, 1916,	–	–	–	–	–	–	–	1,789 65	–	–	1,789 65
Farm,	–	–	–	–	–	–	–	35,143 56	–	–	35,143 56
General horticulture,	–	–	–	–	–	–	–	8,586 92	–	–	8,586 92
Graduate school,	–	–	–	–	–	–	–	134 61	–	–	134 61
Grounds,	–	–	–	–	–	–	–	5,092 93	–	–	5,092 93
Land,	–	–	–	–	–	–	–	8,350 00	–	–	8,350 00
Library,	–	–	–	–	–	–	–	7,269 08	–	–	7,269 08
Miscellaneous,	–	–	–	–	–	–	–	5,434 41	–	–	5,434 41
Operating and maintenance,	–	–	–	–	–	–	–	71,665 52	–	–	71,665 52
Improvement, 1916,	–	–	–	–	–	–	–	2,001 47	–	–	2,001 47
Totals,	$2,912 81	$22,534 65	$36,861 35	$1,059 47	$3,281 11	$1,096 94	$1,392 57	$145,668 45	$602 52	–	$215,409 87
Instruction (salaries),	–	–	–	–	–	–	–	–	–	$144,543 61	144,543 61
Grand total,	–	–	–	–	–	–	–	–	–	–	$394,683 19

Current Accounts.

Disbursements and Receipts.

Accounts.	Disbursements from Nov. 30, 1915, to Nov. 30, 1916.	Receipts from Nov. 30, 1915, to Nov. 30, 1916.	Apportionment for Year ending Nov. 30, 1916.	Balance to Credit.
Administration: —				
Dean's office,	$529 78	-	$500 00	—$29 78
Executive order,	8,421 77	$37 88	9,500 00	1,116 11
President's office,	1,107 51	-	1,000 00	—107 51
Registrar's office,	578 92	-	600 00	21 08
Salaries,	23,020 97	-	22,000 00	—1,020 97
Treasurer's office,	1,070 76	-	1,400 00	329 24
State Treasurer,	-	35,000 00	-	-
Maintenance academic: —				
Agriculture,	1,610 14	124 64	1,400 00	—85 50
Agricultural economics,	228 28	21 00	200 00	—7 28
Agricultural education,	493 27	70 00	460 00	36 73
Agronomy,	738 69	137 75	550 00	—50 94
Animal husbandry,	398 51	280 88	420 00	302 37
Beekeeping,	1,682 36	288 05	1,500 00	105 69
Botany,	1,490 06	1,123 95	825 00	458 89
Chemistry,	5,019 78	2,551 16	2,000 00	—468 62
Dairying,	24,845 24	20,678 17	4,400 00	232 93
Economics and sociology,	39 61	-	50 00	10 39
Entomology,	615 75	91 26	720 00	195 51
Farm administration,	394 84	102 05	400 00	107 21
Floriculture,	6,320 55	3,517 05	2,900 00	96 50
Forestry,	314 48	10 50	375 00	71 02
History and government,	1 40	-	25 00	23 60
Hospital,	1,209 06	25 73	1,500 00	316 67
Landscape gardening,	388 94	254 92	-	-
Language and literature,	368 86	46 25	373 50	50 89
Market gardening,	3,620 35	2,144 94	2,300 00	824 59
Mathematics,	204 37	65 00	250 00	110 63
Microbiology,	1,177 81	446 93	1,125 00	394 12
Military science,	1,598 58	44 23	1,500 00	—54 35
Physical education,	1,020 96	98 50	700 00	—222 46
Physics,	659 80	14 96	600 00	—44 84
Pomology,	3,411 79	1,652 05	1,875 00	115 26
Poultry husbandry,	9,403 41	6,470 41	3,300 00	367 00
Rural engineering,	660 07	215 23	450 00	5 16
Rural sociology,	129 99	1 59	200 00	71 60
Veterinary science,	1,339 60	22 32	1,300 00	—17 28
Zoölogy and geology,	555 17	449 18	350 00	244 01
Maintenance general: —				
Equipment, 1916,	1,789 65	-	-	-
Farm,	35,143 56	28,986 93	3,000 00	—3,156 63
General horticulture,	8,586 92	4,067 29	3,500 00	—1,019 62
Graduate school,	134 61	2 00	200 00	67 39
Grounds,	5,092 93	25 32	5,500 00	432 39
Improvements, 1916,	2,001 47	670 06	-	-
Library,	7,269 08	540 46	6,600 00	—128 62
Miscellaneous,	5,434 41	2,881 15	-	-
Operating and maintenance,	71,665 52	15,915 50	56,000 00	249 98
State Treasurer, maintenance,	-	107,000 00	-	-
Land,	8,350 00	-	10,000 00	1,650 00
Endowment fund,	-	10,613 32	-	-
Instruction: —				
Salaries,	144,543 61	-	-	-
United States Treasurer: —				
Morrill fund,	-	16,666 67	-	-
Nelson fund,	-	16,666 66	-	-
State Treasurer: —				
Instruction,	-	100,000 00	-	-
Graduate school,	-	3,000 00	-	-
Totals,	$394,683 19	$383,021 94	$151,848 50	-
Balance beginning fiscal year Dec. 1, 1915,	-	31,357 66	-	-
Balance on hand Nov. 30, 1916,	19,696 41	-	-	-
Totals,	$414,379 60	$414,379 60	-	-

College Accounts.

Comparative Disbursements and Receipts for 1915–16.

Accounts.	Disbursements.		Receipts.	
	1915.	1916.	1915.	1916.
Agricultural economics,	$164 45	$228 28	$17 25	$21 00
Agricultural education,	508 11	493 27	96	70 00
Agronomy,	445 80	738 69	511 00	137 75
Animal husbandry,	543 75	398 51	280 00	280 88
Beekeeping,	1,597 29	1,682 36	103 79	288 05
Botany,	1,386 06	1,490 06	674 48	1,123 95
Chemistry,	4,661 05	5,019 78	2,961 28	2,551 16
Dairying,	21,917 41	24,845 24	18,696 58	20,678 17
Dean's office,	486 04	529 78	–	–
Economics and sociology,	36 40	39 61	–	–
Entomology,	732 70	615 75	114 06	91 26
Equipment,	7,737 96	1,789 65	–	–
Executive order,	7,915 34	8,421 77	48 85	37 88
Farm administration,	585 11	394 84	28 38	102 05
Farm,	31,441 99	35,143 56	31,985 41[1]	28,986 93
Floriculture,	4,669 08	6,320 55	3,087 20	3,517 05
Forestry,	327 72	314 48	167 40	10 50
General agriculture,	–	1,610 14	–	124 64
General horticulture,	7,234 72	8,586 92	3,819 30	4,067 29
Graduate school,	82 26	134 61	–	2 00
Grounds,	3,616 53	5,092 93	507 70	25 32
History and government,	5 27	1 40	–	–
Hospital,	741 11	1,209 06	30 77	25 73
Improvements,	7,455 01	2,001 47	–	670 06
Land,	–	8,350 00	–	–
Landscape gardening,	446 35	388 94	416 04	254 92
Language and literature,	169 80	368 86	40	46 25
Library,	6,804 27	7,269 08	607 71	540 46
Market gardening,	3,644 91	3,620 35	1,487 65	2,144 94
Mathematics,	263 66	204 37	90 00	65 00
Military,	1,310 48	1,598 58	5 90	44 23
Microbiology,	691 26	1,177 81	450 16	446 93
Miscellaneous,	–	5,434 41	–	2,881 15
Physical education,	922 69	1,020 96	1 25	98 50
Physics,	586 38	659 80	93	14 96
Pomology,	3,472 54	3,411 79	1,805 72	1,652 05
Poultry husbandry,	6,405 28	9,403 41	3,570 90	6,470 41
President's office,	937 99	1,107 51	55	–
Registrar's office,	514 28	578 92	–	–
Rural engineering,	461 98	660 07	106 56	215 23
Rural sociology,	94 00	129 99	1 40	1 59
Salaries,	151,671 88	167,564 58	373 34	–
Treasurer's office,	1,419 46	1,070 76	–	–
Veterinary,	1,235 66	1,339 60	27 13	22 32
Zoölogy and geology,	774 76	555 17	414 75	449 18
Operating and maintenance,	56,541 14	71,665 52	13,603 71	15,915 50
State Treasurer: —				
Endowment fund,	–	–	10,613 32	10,613 32
Graduate school,	–	–	2,000 00	3,000 00
Maintenance,	–	–	105,000 00	107,000 00
Instruction,	–	–	90,000 00	100,000 00
Administration,	–	–	31,000 00	35,000 00
United States Treasurer: —				
Morrill fund,	–	–	16,666 66	16,666 66
Nelson fund,	–	–	16,666 67	16,666 67
Totals,	$342,659 93	$394,683 19	$357,945 16	$383,021 94
Balance beginning fiscal year,	–	–	16,072 43	31,357 66
Balance on hand at close of fiscal year,	31,357 66	19,696 41	–	–
Totals,	$374,017 59	$414,379 60	$374,017 59	$414,379 60

[1] This large amount of receipts is due to the sale of milk the last three months of 1914, paid in 1915.

College Accounts — *Concluded.*

Summary.

	Disbursements.	Receipts.
Cash on hand Dec. 1, 1915,		$31,357 66
Institution receipts Nov. 30, 1916,		94,075 29
State Treasurer's receipts Nov. 30, 1916,		255,613 32
United States Treasurer's receipts Nov. 30, 1916,		33,333 33
Total disbursements,	$394,683 19	-
	$394,683 19	$414,379 60
Bills receivable Dec. 1, 1915, deducted,		5,669 36
Bills payable Dec. 1, 1916, deducted,	2,742 27	
	$391,940 92	$408,710 24
Bills receivable Nov. 30, 1916,	-	8,077 39
Bills payable Nov. 30, 1916,	6,250 83	-
Balance,	18,595 88	-
	$416,787 63	$416,787 63

255
31
55
341

Farm Disbursements.

	Labor.	Equipment.	Feed.	Fertilizer.	Seeds.	Stock.	Supplies.	Improvements.	Totals.
Cattle,	$5,850 00	–	$6,203 77	–	–	–	$399 65	–	$12,453 42
Dairy,	2,119 27	$114 04	–	–	–	–	2,577 05	–	4,810 36
Horses,	2,279 03	–	1,383 83	–	–	$325 20	381 25	–	4,369 31
Sheep,	203 97	–	136 45	–	–	–	65 40	–	405 82
Swine,	608 58	–	1,436 29	–	–	–	79 43	–	2,124 30
Field crops,	3,712 13	–	–	$1,143 09	$431 96	–	121 56	–	5,408 74
Miscellaneous,	2,269 77	–	–	–	–	–	125 67	$1,612 16	4,007 60
Tools and machinery,	–	–	–	–	–	–	393 64	–	393 64
Live stock,	–	–	–	–	–	–	1,170 37	–	1,170 37
Totals,	$17,042 75	$114 04	$9,160 34	$1,143 09	$431 96	$325 20	$5,314 02	$1,612 16	$35,143 56

Farm Credits.

	Milk.	Stock.	Sundry.	Hay.	Roots.	Labor.	Potatoes.	Totals.
Cattle,	–	$1,728 50	$180 53	–	–	–	–	$1,909 03
Dairy,	$21,207 85	–	–	–	–	–	–	21,207 85
Horses,	–	135 00	719 34	–	–	–	–	854 34
Sheep,	–	126 00	84 50	–	–	–	–	210 50
Swine,	–	1,856 85	2 00	–	–	–	–	1,858 85
Field crops,	–	–	–	$602 94	$463 15	–	$525 95	1,592 04
Miscellaneous,	–	–	367 75	–	–	$986 57	–	1,354 32
Totals,	$21,207 85	$3,846 35	$1,354 12	$602 94	$463 15	$986 57	$525 95	$28,986 93

Agricultural Division.

Disbursements and Receipts.

	Disbursements.	Receipts.
Agronomy,	$738 69	$137 75
Animal husbandry,	398 51	280 88
Dairying,	24,845 24	20,678 17
Farm,	35,143 56	28,986 93
Farm administration,	394 84	102 05
Poultry husbandry,	9,403 41	6,470 41
Rural engineering,	660 07	215 23
Division totals,	$71,584 32	$56,871 42

Summary.

	Dr.	Cr.
By total division receipts,		$56,871 42
By bills receivable,		4,823 32
By net apportionment,		12,520 00
To total disbursements,	$71,584 32	
To bills payable,	3,118 60	
Balance,		488 18
	$74,702 92	$74,702 92

Inventory of Quick Assets.

	Nov. 30, 1915.	Nov. 30, 1916.
Inventory of produce,	$11,518 42	$8,533 40
Inventory of cattle,	14,945 00	14,200 00
Inventory of swine,	900 00	1,505 00
Inventory of horses,	5,425 00	6,765 00
Inventory of poultry,	1,162 25	2,277 00
Inventory of sheep,	591 00	668 00
	$34,541 67	$33,948 40

Horticultural Division.

Disbursements and Receipts.

	Disbursements.	Receipts.
Floriculture,	$6,320 55	$3,517 05
Forestry,	314 48	10 50
General horticulture,	8,586 92	4,067 29
Grounds,	5,092 93	25 32
Landscape gardening,	388 94	254 92
Market gardening,	3,620 35	2,144 94
Pomology,	3,411 79	1,652 05
Division totals,	$27,735 96	$11,672 07

Summary.

	Dr.	Cr.
By total division receipts,		$11,672 07
By bills receivable,		1,232 85
By apportionment,		16,450 00
To total division disbursements,	$27,735 96	
To bills payable,	535 69	
By balance,	1,083 27	
	$29,354 92	$29,354 92

Inventory of Quick Assets.

	Nov. 30, 1915.	Nov. 30, 1916.
Floriculture,	$550 00	$500 00
Market gardening,	121 50	150 00
Pomology,	375 00	575 00
General horticulture (live stock),	1,695 00	1,750 50
	$2,741 50	$2,975 50

Expense Operating and Maintenance.

	Salaries.	Labor.	Fuel and Water.	Repairs.	Supplies.	Tools.	Architect.	Engineer.	Miscellaneous.	Totals.
General: —										
General superintendent,	$3,201 73	-	-	-	-	-	-	-	-	$3,201 73
Office,	-	$1,075 65	-	-	-	-	-	-	-	1,075 65
General expense,	-	-	-	-	$3,288 75	-	-	-	-	3,288 75
Power plant: —										
Heat,	-	6,152 89	$30,806 05	$1,177 24	$104 94	-	-	-	-	38,241 12
Light,	-	526 61	16 79	279 33	69 41	-	-	-	-	892 14
Tools,	-	-	-	-	-	$1,129 61	-	-	-	1,129 61
Gas mains,	-	5 72	-	-	-	-	-	-	-	5 72
Amherst Water Company,	-	-	2,187 36	-	-	-	-	-	-	2,187 36
Night watchman,	-	1,344 05	-	-	-	-	-	-	-	1,344 05
Mail service	-	246 31	-	-	-	-	-	-	-	246 31
Water mains,	-	101 23	-	-	-	-	-	-	-	101 23
Steam mains,	-	949 89	-	-	-	-	-	-	-	949 89
Electric light circuit,	-	304 91	-	-	-	-	-	-	-	304 91
Waiting station janitor,	-	5 90	-	-	-	-	-	-	-	5 90
Miscellaneous sundry,	-	-	-	-	-	-	-	-	$5,963 46	5,963 46
Sewers and cesspools,	-	31 80	-	-	-	-	-	-	-	31 80
Walks,	-	75 37	-	-	-	-	-	-	-	75 37
Emergency maintenance,	-	1,531 31	-	-	-	-	-	-	-	1,531 31
Expert services,	-	-	-	-	-	-	$1,098 17	$49 15	-	1,147 32
Fire department,	660 00	77 92	-	-	29 71	-	-	-	1 75	769 38
Amherst Gas Company,	-	-	55 52	-	-	-	-	-	-	55 52
Totals,	$3,861 73	$12,429 56	$33,065 72	$1,456 57	$3,492 81	$1,129 61	$1,098 17	$49 15	$5,965 21	$62,548 53

EXPENSE OPERATING AND MAINTENANCE — *Concluded.*

College Buildings.	Electric Repairs.	Plumbing Repairs.	Heat Repairs.	C. and M. Repairs.	Janitor.	Bell Ringing.	Sundry.	Totals.
College buildings: —								
Animal husbandry building,	$1 07	$2 33	$5 87	$1 07	-	-	-	$10 34
Horse barn,	5 37	2 40	28	120 67	-	-	-	128 72
Dairy barn,	8 97	44 66	69 17	31 99	-	-	-	154 79
Young stock barn,	-	38	-	8 25	-	-	-	8 63
Power building,	6 34	47 55	-	134 69	$248 65	-	-	437 23
Chemical building,	1 91	62 00	12 28	63 49	-	-	-	139 68
Poultry building,	6 89	23 58	4 21	20 78	-	-	-	55 46
Dairy building,	41 44	65 89	44 25	306 95	-	-	-	458 53
Drill hall,	5 73	36 44	24 88	157 60	-	-	-	224 65
Veterinary building,	2 28	9 00	91	73 32	-	-	-	85 51
Apiary building,	2 80	10 49	2 18	45 78	-	-	-	61 25
Mathematic building,	-	86	42 32	15 12	-	-	-	58 30
Entomology building,	23 33	64 92	18 84	229 81	-	-	-	336 90
Clark hall,	13 93	68 65	23 71	203 87	-	-	-	310 16
French hall,	12 55	15 42	19 53	74 99	-	-	-	122 49
Wilder hall,	41 70	6 55	27 36	7 51	-	-	-	83 12
Upper plant house,	-	10 09	11 26	7 73	-	-	-	29 08
Old Durfee range,	-	59	14 63	35 96	-	-	-	51 18
Horticultural barn,	62	-	-	74 38	-	-	-	75 00
Physics building,	27 52	8 41	15 96	16 22	-	-	-	68 11
East experiment station,	34	37 03	62 05	7 82	-	-	-	107 24
West experiment station,	11 10	39 59	21 71	166 42	-	-	-	238 82
Experiment station barn,	-	18 95	57 07	7 35	-	-	-	83 37
Rural engineering building,	7 67	-	17 82	18 61	-	-	-	44 10
Microbiology building,	45 50	9 75	3 27	18 80	-	-	$150 00	227 32
Draper hall,	36 91	174 87	67 19	487 33	-	-	880 60	1,646 90
Hospital,	4 35	20 15	9 59	54 96	-	-	-	89 05
Stockbridge hall,	116 43	57 50	7 56	278 83	-	-	13 00	473 32
Cold-storage building,	-	-	-	3 14	-	-	-	3 14
Machine barn,	-	8 84	-	1 90	-	-	-	10 74
Sheep barn,	-	7 01	-	52 07	-	-	-	59 08
Piggery,	-	-	-	28	-	-	-	28
Quarantine barn,	-	-	-	78 75	-	-	-	78 75
Poultry demonstration house,	-	-	-	42 77	-	-	-	42 77
Poultry feed house,	-	-	-	24 00	-	-	-	24 00
Poultry brooding house,	-	-	-	1 18	-	-	-	1 18

Poultry killing house,	-	-	-	48	-	-	-	48
Poultry judging house,	-	-	-	30 04	-	-	-	30 04
Poultry colony house,	-	-	-	3 58	-	-	-	3 58
North College,	81 39	30 28	11 46	134 69	523 41	-	79 50	860 73
South College,	81 03	70 80	19 96	214 71	510 93	-	81 00	978 43
Chapel,	40 93	39 28	2 59	45 77	148 41	$125 00	-	401 98
College residences: —								
Harlow place,	-	-	-	97 84	-	-	-	97 84
Kellogg place,	24	21 34	-	40 21	-	-	10 31	72 10
Goldberg place,	-	1 12	-	-	-	-	-	1 12
President's house,	2 58	14 61	8 70	216 90	-	-	-	242 79
Waugh house,	1 70	3 26	7 83	72 19	-	-	-	84 98
Registrar's house,	-	-	6 11	26	-	-	-	6 37
Farm superintendent's house,	3 75	21 25	27 94	117 64	-	-	-	170 58
Farm help's house,	-	10 64	-	27 69	-	-	8 40	46 73
Stockbridge house,	-	4 10	-	11 30	-	-	-	15 40
Farm cottage,	-	27 21	44 40	3 04	-	-	-	74 65
Totals,	$636 37	$1,097 79	$712 89	$3,890 73	$1,431 40	$125 00	$1,222 81	$9,116 99

Summary.

General,	$62,548 53
College buildings,	8,304 43
College residences,	812 56
Total,	$71,665 52

Experiment Station.

Disbursements and Receipts.

Accounts.	Disbursements from Dec. 1, 1915, to Nov. 30, 1916.	Receipts from Dec. 1, 1915, to Nov. 30, 1916.	Apportionment for Year ending Nov. 30, 1916.	Balance to Credit.
Administration,	$1,029 25	$13 46	$1,200 00	$184 21
Agricultural economics,	650 24	-	1,000 00	349 76
Agricultural,	7,417 23	5,080 69	3,100 00	763 46
Apiculture,	102 73	-	100 00	—2 73
Asparagus,	12 26	-	350 00	337 74
Botanical,	1,589 04	30 00	1,600 00	40 96
Chemical,	12,069 86	12,002 98	1,000 00	933 12
Cranberry,	3,106 97	2,771 12	3,000 00	2,664 15
Entomological,	452 21	-	600 00	147 79
Equipment,	717 02	-	750 00	32 98
Feed inspection,	5,632 53	6,000 00	-	-
Fertilizer inspection,	11,434 88	9,400 00	-	-
Freight and express,	382 33	91 26	400 00	108 93
Graves' orchard,	658 13	1,131 15	800 00	1,273 02
Horticultural,	1,700 83	53 08	1,600 00	—47 75
Library,	682 10	-	700 00	17 90
Microbiology,	273 80	-	1,000 00	726 20
Meteorology,	369 11	-	375 00	5 89
Poultry,	1,811 21	-	1,800 00	—11 21
Publications,	795 14	-	800 00	4 86
Salaries,	42,986 41	-	43,400 00	413 59
Tillson Farm,	1,921 78	320 96	500 00	—1,100 82
Treasurer's office,	181 70	-	425 00	243 30
Veterinary,	943 73	-	725 00	—218 73
Hatch fund,	-	15,000 00	-	-
Adams fund,	-	15,000 00	-	-
State fund,	-	30,000 00	-	-
Blood test,	34 10	506 00	-	-
Totals,	$96,954 59	$97,400 70	$65,225 00	-
Balance beginning fiscal year Dec. 1, 1915.	-	8,077 29	-	-
Balance on hand Nov. 30, 1916,	8,523 40	-	-	-
	$105,477 99	$105,477 99	-	-

Experiment Station — *Continued.*

Comparative Disbursements and Receipts, 1915–16.

Accounts.	Disbursements.		Receipts.	
	1915.	1916.	1915.	1916.
Administration,	$1,011 28	$1,029 25	$34 72	$13 46
Agriculture,	5,247 13	7,417 23	2,365 01	5,080 69
Asparagus,	701 48	12 26	–	–
Botanical,	1,469 01	1,589 04	3 00	30 00
Chemical,	11,015 52	12,069 86	10,732 09	12,002 98
Cranberry,	3,015 05	3,106 97	2,437 01	2,771 12
Entomology,	477 98	452 21	–	–
Feed inspection,	5,337 54	5,632 53	6,000 00	6,000 00
Fertilizer inspection,	10,047 01	11,434 88	10,088 00	9,400 00
Freight and express,	311 55	382 33	32	91 26
Graves' orchard,	737 73	658 13	1,027 19	1,131 15
Horticultural,	1,803 75	1,700 83	187 64	53 08
Library,	855 91	682 10	–	–
Meteorology,	278 49	369 11	–	–
Poultry,	2,034 82	1,811 21	4 33	–
Publications,	818 66	795 14	–	–
Salaries,	39,199 74	42,986 41	–	–
Treasurer's office,	377 87	181 70	–	–
Veterinary,	238 11	943 73	–	–
Equipment,	1,821 22	717 02	–	–
Agricultural economics,	605 94	650 24	–	–
Apiculture,	–	102 73	–	–
Microbiology,	773 08	273 80	–	–
Miscellaneous,	–	–	90 00	–
Tillson farm,	–	1,921 78	–	320 96
Blood test,	–	34 10	–	506 00
Hatch fund,	–	–	15,000 00	15,000 00
Adams fund,	–	–	15,000 00	15,000 00
State fund,	–	–	25,000 00	30,000 00
Totals,	$88,178 87	$96,954 59	$87,969 31	$97,400 70
Balance at beginning of fiscal year,	–	–	8,286 85	8,077 29
Balance on hand at close of fiscal year,	8,077 29	8,523 40	–	–
	$96,256 16	$105,477 99	$96,256 16	$105,477 99

EXPERIMENT STATION — *Concluded.*

Analysis of Experiment Station Accounts.

	Adams Fund.	Feed Law.	Fertilizer Law.	Hatch Fund.	State Fund.	Totals.
Salaries,	$15,357 88	$4,218 71	$7,490 42	$14,883 69	$12,744 84	$54,695 54
Labor,	–	267 73	1,315 59	–	20,683 93	22,267 25
Publications,	–	24 50	633 00	–	425 89	1,083 39
Postage and stationery,	–	39 10	192 76	–	1,391 19	1,623 05
Freight and express,	–	–	43 79	–	431 51	475 30
Heat, light, water and power,	–	42 50	174 03	–	180 61	397 14
Chemical and laboratory supplies,	–	162 65	688 66	–	977 09	1,828 40
Seeds, plants and sundry supplies,	–	74 56	62 86	–	2,584 81	2,722 23
Fertilizers,	–	–	–	–	868 16	868 16
Feeding stuffs,	–	–	–	–	1,896 68	1,896 68
Library,	–	8 10	–	–	791 27	799 37
Tools, machinery and appliances,	–	6 75	30 24	–	764 89	801 88
Furniture and fixtures,	–	–	3 30	–	303 93	307 23
Scientific apparatus and specimens,	–	–	26 21	–	311 97	338 18
Live stock,	–	350 00	–	–	457 65	807 65
Traveling expenses,	–	435 04	749 02	–	2,492 50	3,676 56
Contingent expenses,	–	–	–	–	30 00	30 00
Buildings and land,	–	2 89	25 00	–	2,247 72	2,275 61
Equipment,	–	–	–	–	60 97	60 97
Totals,	$15,357 88	$5,632 53	$11,434 88	$14,883 69	$49,645 61	$96,954 59

Summary.

	Disbursements.	Receipts.
Cash on hand Dec. 1, 1915,	–	$8,080 12
Receipts from State Treasurer,	–	36,000 00
Receipts from United States Treasurer,	–	30,000 00
Receipts from other sources,	–	31,400 70
Total disbursements,	$96,954 59	–
	$96,954 59	$105,480 82
Bills receivable Dec. 1, 1915, deducted,	–	865 22
Bills payable Dec. 1, 1915, deducted,	862 39	–
	$96,092 20	$104,615 60
Bills receivable Nov. 30, 1916,	–	2,776 06
Bills payable Nov. 30, 1916,	865 00	–
Balance,	10,434 46	–
	$107,391 66	$107,391 66

Extension Service.

Disbursements and Receipts.

Classification.	Disbursements.	Receipts.	Apportionment.	Balance.
Administration,	$1,502 91	$92 05	$1,700 00	$289 14
Director's office,	1,263 32	44 28	1,300 00	80 96
Salaries,	29,646 19	121 67	29,862 59	338 07
Correspondence courses,	1,078 64	696 96	200 00	—181 68
Civic improvement,	1,310 16	986 11	450 00	125 95
Community planning,	697 86	2 25	550 00	—145 61
Library extension,	199 93	-	200 00	07
Lectures,	221 23	1 00	500 00	279 77
Exhibits,	1,250 26	525 00	500 00	—225 26
Equipment,	704 91	-	1,800 00	1,095 09
Pomology,	284 54	88 20	400 00	203 66
Printing and publicity,	967 09	134 92	1,000 00	167 83
Animal husbandry,	230 22	2 00	350 00	121 78
Agricultural education,	2,386 27	53	2,300 00	—85 74
Farm management,	397 26	109 50	100 00	—187 76
Poultry husbandry,	99 21	9 78	150 00	60 57
Home economics,	354 81	-	350 00	—4 81
Short courses,	11,520 87	2,805 78	9,220 00	504 91
Dairying,	71 91	-	200 00	128 09
County and local agents,	463 65	24 20	520 00	80 55
Agricultural economics,	690 62	17 79	600 00	—72 83
Reserve and emergency,	-	-	9,357 14	-
State treasurer,	-	50,000 00	-	-
Totals,	$55,341 86	$55,662 02	$61,609 73	$2,572 75
Balance at beginning of fiscal year Dec. 1, 1915,	-	11,719 54	-	-
Balance on hand Dec. 1, 1916,	12,039 70	-	-	-
Totals,	$67,381 56	$67,381 56	-	-

Summary.

	Disbursements.	Receipts.
Balance Dec. 1, 1915,	-	$12,622 56
Receipts Nov. 30, 1916,	-	5,662 02
Received from State Treasurer,	-	50,000 00
Received from United States Treasurer,	-	14,151 90
Disbursements to Nov. 30, 1916,	$69,883 31[1]	-
	$69,883 31	$82,436 48
Bills receivable Dec. 1, 1915, deducted,	-	152 00
Bills payable Dec. 1, 1915, deducted,	594 31	-
	$69,289 00	$82,284 48
Bills receivable Nov. 30, 1916,	-	622 12
Bills payable Nov. 30, 1916,	116 87	-
Balance,	13,500 73	-
	$82,906 60	$82,906 60

[1] Includes Federal Smith-Lever fund.

EXTENSION SERVICE — *Concluded.*

Analysis of Extension Service Disbursements.

	Travel.	Equipment.	Printing.	Supplies.	Instruction and Lectures.	Salaries.	Miscel-laneous.	Totals.
Administration,	$790 68	–	–	$694 38	–	–	$17 85	$1,502 91
Agricultural education,	915 25	$177 81	–	999 03	–	–	461 99	2,554 08
Agricultural economics,	582 96	29 15	–	107 66	–	–	–	719 77
Animal husbandry,	144 22	–	–	86 00	–	–	–	230 22
Agricultural camps,	40 15	–	–	587 01	–	–	25 00	652 16
Apple packing,	–	–	–	29 32	–	–	–	29 32
Bankers' conference,	109 80	–	–	45 25	–	–	–	155 05
Beekeeping,	1 44	–	–	123 89	–	–	–	125 33
Civic improvements,	526 82	27 65	–	783 34	–	–	–	1,337 81
Community planning,	587 40	40 00	–	110 46	–	–	–	737 86
Conference rural community planning,	–	–	–	37 59	–	–	–	37 59
Correspondence courses,	153 68	40 08	–	924 96	–	–	–	1,118 72
County agents,	442 57	88 27	–	21 08	–	–	–	551 92
County agents' conference,	22 25	–	–	35 04	–	–	–	57 29
Dairying,	4 87	–	–	67 04	–	–	–	71 91
Directors' office,	–	134 38	–	1,231 21	–	–	32 11	1,397 70
Exhibits,	85 68	–	–	–	–	–	1,164 58	1,250 26
Farmers' week,	643 47	–	–	271 00	$398 55	–	–	1,313 02
Home economics,	185 18	48 02	–	169 63	–	–	–	402 83
Library extension,	–	–	–	199 93	–	–	–	199 93
Miscellaneous,	–	–	–	34 06	–	–	–	34 06
Pomology,	155 73	109 05	–	128 81	–	–	–	393 59
Poultry convention,	10 95	–	–	313 76	–	–	–	324 71
Poultry husbandry,	39 53	10 50	–	59 68	–	–	–	109 71
Printing and publications,	47 70	–	–	919 39	–	–	–	967 09
Salaries,	–	–	–	–	–	$32,043 69	–	32,043 69
Supervision,	–	–	–	58	–	–	–	58
Summer school,	80 02	–	$400 56	838 36	3,032 56	–	111 65	4,463 15
Ten weeks' course,	–	–	265 28	1,031 23	604 60	–	30 00	1,931 11
Farm demonstration,	–	–	–	397 26	–	–	–	397 26
Lectures,	43 71	–	–	–	–	–	177 52	221 23
Totals,	$5,614 06	$704 91	$665 84	$10,246 95	$4,035 71	$32,043 69	$2,020 70	$55,331 86

SMITH-LEVER FUND (FEDERAL).

	Disbursements.	Receipts.
Salaries,	$8,900 37	–
Home economics,	623 24	–
Animal husbandry,	412 92	–
Dairying,	288 20	–
Pomology,	382 30	–
Farm management,	473 10	–
Boys' and Girls' Club,	1,174 48	–
Poultry,	682 38	–
Extension school,	328 57	–
Publications and printing,	924 08	–
State leader,	351 81	–
State Treasurer,	–	$14,151 90
Totals,	$14,541 45	$14,151 90
Balance at beginning of fiscal year, Dec. 1, 1915,	–	1,984 58
Balance on hand Nov. 30, 1915,	1,595 03	–
	$16,136 48	$16,136 48

SPECIAL APPROPRIATIONS.

	Date made.	Amount of Apportionment.	Amount previously expended.	Amount expended during Fiscal year.	Amount expended to Date.	Amount received from State Treasurer.	Balance on Hand with State Treasurer.
Agricultural building,	1914	$210,000 00	$192,824 67	$16,109 87	$208,934 54	$208,934 54	$1,065 46
Microbiology building,	1915	67,500 00	14,754 27	47,935 38	62,689 65	62,689 65	4,810 35
Improvements and equipment,	1916	20,000 00	-	17,336 77	-	-	2,663 23
Agricultural building,	1916	13,732 34	-	12,243 49	-	-	1,488 85
Retaining wall and platform,	1916	4,200 00	-	4,200 00	-	-	-
Rural engineering shop,	1916	12,000 00	-	9,617 67	-	-	2,382 33
Totals,	. .	$327,432 34	$207,578 94	$107,443 18	$271,624 19	$271,624 19	$12,410 22

Inventory — Real Estate.

Land (Estimated Value).

Allen place,	$500 00
Baker place,	2,500 00
Bangs place,	2,350 00
Brown land,	500 00
Charmbury place,	450 00
Clark place,	4,500 00
College farm,	37,000 00
Cranberry land,	10,975 50
Dickinson land,	7,850 00
Harlow farm,	3,284 63
Hawley and Brown place,	675 00
Kellogg farm,	5,868 45
Loomis place,	415 00
Louisa Baker place,	5,000 00
Newell farm,	2,800 00
Old creamery place,	1,000 00
Owen farm,	5,000 00
Pelham quarry,	500 00
Wescott place,	2,250 00
Total,	$93,418 58

College Buildings (Estimated Value).

	Inventory at Beginning of Year.	Per Cent.	Value at Beginning of Year less Per Cent. Deterioration.	Repairs and Improvements during Year.	Total Value.
Apiary,	$3,042 08	2	$2,981 24	$61 25	$3,042 49
Animal husbandry building,	9,825 50	2	9,62 99	10 34	9,639 33
Chemical laboratory,	7,735 90	5	7,349 10	1,014 03	8,363 13
Clark hall,	66,459 04	2	65,129 86	541 30	65,671 16
Cold-storage laboratory,	11,851 09	2	11,614 07	3 14	11,617 21
Dairy building,	74,224 17	2	72,739 69	458 53	73,198 22
Dairy barn and storage,	29,180 06	3	28,304 66	417 34	28,722 00
Dining hall,	58,703 87	3	56,942 75	766 30	57,709 05
Drill hall and gun shed,	9,640 28	5	9,158 27	224 97	9,383 24
Durfee glass houses, old,	9,548 50	5	9,071 07	51 18	9,122 25
Durfee glass houses, new,	14,576 72	5	13,847 88	–	13,847 88
Entomology building,	78,773 17	2	77,197 71	360 51	77,558 22
Farm bungalow,	2,046 63	3	1,985 23	74 65	2,059 88
Farmhouse,	2,482 07	3	2,407 61	170 58	2,578 19
French hall,	49,710 76	2	48,716 54	122 49	48,839 03
Horse barn,	4,875 71	3	4,729 44	128 72	4,858 16
Horticultural barn,	2,497 83	3	2,422 90	92 70	2,515 60
Horticultural tool shed,	1,940 00	3	1,881 80	–	1,881 80
Hospital,	15,452 28	2	15,143 23	89 05	15,232 28
Machinery barn,	3,885 07	3	3,768 52	10 74	3,779 26
Mathematical building,	5,751 14	5	5,463 58	58 30	5,521 88
Microbiology building,	–	–	62,144 41	–	62,144 41
North dormitory,	24,804 44	2	24,308 35	257 82	24,566 17
Physics laboratory,	5,339 06	5	5,072 11	68 11	5,140 22
Piggery,	2,920 47	3	2,832 86	28	2,833 14

College Buildings (Estimated Value) — Concluded.

	Inventory at Beginning of Year.	Per Cent.	Value at Beginning of Year less Per Cent. Deterioration.	Repairs and Improvements during Year.	Total Value.
Poultry department: —					
Breeding houses,	$1,568 00	2	$1,536 64	–	$1,536 64
Brooder house,	1,083 55	2	1,061 88	$1 18	1,063 06
Incubator cellar and building,	1,372 00	2	1,344 56	42 77	1,387 33
Incubator cellar and storage building,	800 00	2	784 00	727 12	1,511 12
Crematory,	50 00	2	49 00	–	49 00
Duck house,	100 00	2	98 00	–	98 00
Killing and fattening laboratory,	1,345 51	2	1,318 60	30 52	1,349 12
Laying house,	1,764 00	2	1,728 72	–	1,728 72
Mechanics and storage building,	1,894 67	2	1,856 78	79 46	1,936 24
Transfer house,	–	–	504 60	–	504 60
Power plant and storage building, including coal pocket,	30,872 28	2	30,254 83	5,024 89	35,279 72
President's house,	11,881 21	3	11,524 77	258 06	11,782 83
Quarantine barn,	194 00	3	188 18	329 31	517 49
Rural engineering building,	3,550 00	2	3,479 00	127 06	3,606 06
Sheep barn,	1,415 66	3	1,373 19	59 08	1,432 27
South dormitory,	35,248 44	2	34,543 47	981 88	35,525 35
Stockbridge hall,	184,000 00	2	180,320 00	1,136 73	181,456 73
Agronomy greenhouse,	2,150 00	2	2,107 00	–	2,107 00
Stone chapel,	29,510 58	2	28,920 37	147 64	29,068 01
Three houses on Stockbridge Road,	5,175 10	5	4,916 34	106 75	5,023 09
Vegetable plant house,	4,593 31	5	4,363 64	29 08	4,392 72
Veterinary laboratory and stable,	23,127 39	2	22,664 84	759 03	23,423 87
Waiting station,	495 80	2	485 88	5 90	491 78
Wilder hall,	36,812 29	2	36,076 04	83 12	36,159 16
Young stock barn,	6,419 50	3	6,226 91	8 63	6,235 54
Totals,	$880,689 13	–	$922,569 11	$14,920 54	$937,489 65

College Equipment (Estimated Value).

Administrative division: —	
Dean's office,	$519 05
President's office,	1,564 25
Registrar's office,	931 46
Treasurer's office,	2,571 25
Agricultural division: —	
Agronomy,	6,710 90
Animal husbandry,	810 61
Dairy,	16,584 94
Farm administration,	1,119 67
Farm management,	37,596 58
General agriculture,	4,214 78
Poultry,	4,357 69
Rural engineering,	2,848 63
Dining hall,	6,843 86
Extension,	12,825 19
General science: —	
Apiary,	1,846 02
Botanical,	15,046 25
Chemical,	11,160 68
Entomology,	6,242 32
Microbiology,	7,017 37

General science — *Concluded.*		
Mathematics,		$2,367 50
Physics,		5,349 57
Veterinary,		10,439 93
Zoölogical laboratory,		10,142 93
Zoölogical museum,		6,511 05
Graduate school,		97 88
Horticultural division: —		
Floriculture,		8,039 57
Forestry,		2,326 60
General horticulture,		7,602 47
Grounds,		820 75
Landscape gardening,		4,971 66
Market gardening,		1,507 68
Pomology,		5,772 61
Hospital,		945 38
Humanities, division of: —		
Economics and sociology,		142 17
Language and literature,		422 50
Library,		89,655 85
Military,		1,494 32
Operating and maintenance: —		
College supply,		1,127 62
Fire apparatus,		1,851 15
General maintenance,		93,239 00
Equipment,	$79,769 17	
Carpentry and masonry supplies,	4,181 08	
Electrical supplies,	2,127 02	
Heating and plumbing supplies,	6,294 38	
Painting supplies,	867 35	
Janitors' supplies,		870 51
Sewer line,		12,385 50
Water mains,		10,911 66
Physical education,		2,511 00
Rural social science: —		
Agricultural economics,		563 95
Agricultural education,		499 99
Rural sociology,		258 02
Textbooks,		527 39
Trophy room,		1,564 74
Total,		$425,732 45

Experiment Station Buildings (Estimated Value).

	Inventory at Beginning of Year.	Per Cent.	Cost at Beginning of Year less Per Cent. Deterioration.	Repairs and Improvements.	Total Value.
Agricultural laboratory,	$15,162 51	2	$14,859 26	$107 24	$14,966 50
Agricultural barns,	4,882 27	3	4,735 80	41 67	4,777 47
Agricultural farmhouse,	1,455 00	3	1,411 35	1 12	1,412 47
Agricultural glass house,	475 00	5	451 25	–	451 25
Cranberry buildings,	2,645 00	–	2,490 00	–	2,490 00
Plant and animal chemistry laboratory,	29,512 13	2	28,921 89	238 82	29,160 71
Plant and animal chemistry barns,	3,999 28	3	3,879 30	41 68	3,920 98
Plant and animal chemistry dairy,	1,940 00	3	1,881 80	–	1,881 80
Six poultry houses,	588 00	2	576 24	–	576 24
Entomological glass houses,	783 75	5	744 56	–	744 56
Totals,	$61,442 94	–	$59,951 45	$430 53	$60,381 98

Experiment Station Equipment (Estimated Value).

Agricultural laboratory,	$7,212 13
Botanical laboratory,	6,465 74
Chemical laboratory,	22,147 02
Cranberry station,	3,052 53
Director's office,	5,071 45
Entomological laboratory,	23,562 45
Horticultural laboratory,	4,159 05
Meteorology laboratory,	855 00
Microbiology laboratory,	577 45
Poultry department,	5,312 03
Treasurer's office,	1,118 00
Veterinary laboratory,	40 16
Total,	$79,573 01

Inventory Summary.

Land,	$93,418 58
College buildings,	937,489 65
College equipment,	425,732 45
Experiment station buildings,	60,381 98
Experiment station equipment,	79,573 01
Total,	$1,596,595 67

Students' Trust Fund Account.

	Disbursements for Year ending Nov. 30, 1915.	Receipts for Year ending Nov. 30, 1916.	Balance on Hand.	Balance brought forward Dec. 1, 1915.
Athletics,	$9,879 20	$9,341 80	$1,804 51	$2,341 91
College signal,	8 73	–	–	8 73
Dining hall,	60,698 73	54,809 34	—12,005 19	—6,115 80
Keys,	89 25	80 00	35 75	45 00
Student deposits,	19,226 23	20,142 00	8,057 24	7,141 47
Social union,	890 39	1,125 19	934 40	699 60
Textbooks,	4,535 59	4,781 07	1,181 87	936 39
Athletic field,	639 75	1,584 69	—252 22	—1,197 16
Uniforms,	3,589 90	2,704 85	2,423 64	3,308 69
1916 index,	400 00	394 24	–	5 76
Totals,	$99,957 77	$94,963 18	$2,180 00	$7,174 59
Balance on hand Dec. 1, 1915,	–	7,174 59	–	–
Balance on hand Nov. 30, 1916,	2,180 00	–	–	–
	$102,137 77	$102,137 77	–	–

Detailed Statement of Dining Hall.

		Liabilities.	Resources.
1915. Dec. 1.	Balance,	$6,115 80	
1916. Nov. 30.	Total disbursements,	60,698 73	
	Outstanding bills,	3,860 88	
	Total collections,		$54,809 34
	Accounts outstanding,		2,174 03
	Inventory,		3,110 30
	Balance,		10,581 74
		$70,675 41	$70,675 41

Endowment Fund.[1]

	Principal.	Income.
United States grant (5 per cent.),	$219,000 00	$7,300 00
Commonwealth grant (3½ per cent.),	142,000 00	3,313 32
	–	$10,613 32

[1] This fund is in the hands of the State Treasurer, and the Massachusetts Agricultural College receives two-thirds of the income from the same.

Burnham Emergency Fund.

	Market Value Dec. 1, 1916.	Par Value.	Income.
Two bonds American Telephone and Telegraph Company 4s, at $910,	$1,820 00	$2,000 00	$80 00
Two bonds Western Electric Company 5s, at $1,000,	2,000 00	2,000 00	100 00
	$3,820 00	$4,000 00	$180 00
Unexpended balance Dec. 1, 1915,	–	–	320 55
Cash on hand Nov. 30, 1916,	–	–	$500 55

Library Fund.

Five bonds New York Central & Hudson River Railroad Company 4s, at $930,	$4,650 00	$5,000 00	$200 00
Five bonds Lake Shore & Michigan Southern Railroad Company 4s, at $950,	4,750 00	5,000 00	200 00
Two shares New York Central & Hudson River Railroad Company stock, at $102,	204 00	200 00	10 00
Amherst Savings Bank, deposit,	167 77	167 77	7 09
	$9,771 77	$10,367 77	$417 09
Nov. 20, 1916, transferred to college library account,	–	–	417 09

Special Funds.

Endowed Labor Fund (the Gift of a Friend of the College).

Two bonds American Telephone and Telegraph Company 4s, at $910,	$1,820 00	$2,000 00	$80 00
Two bonds Lake Shore & Michigan Southern Railroad Company 4s, at $950,	1,900 00	2,000 00	80 00
One bond New York Central Railroad debenture 4s,	930 00	1,000 00	40 00
Amherst Savings Bank, deposit,	143 39	143 39	6 07
One bond Metropolitan Street Railway of Kansas City, 5s,	950 00	1,000 00	100 00
	$5,743 39	$6,143 39	$306 07
Unexpended balance Dec. 1, 1915,	–	–	230 97
Cash on hand Nov. 30, 1916,	–	–	$537 04

Whiting Street Scholarship Fund.

One bond New York Central debenture 4s,	$930 00	$1,000 00	$40 00
Amherst Savings Bank, deposit,	271 64	271 64	11 51
	$1,201 64	$1,271 64	$51 51
Unexpended balance Dec. 1, 1915,	–	–	187 67
Cash on hand Nov. 30, 1916,	–	–	$239 18

SPECIAL FUNDS — *Continued.*

Hills Fund.

	Market Value Dec. 1, 1916.	Par Value.	Income.
One bond American Telephone and Telegraph Company 4s, at	$910 00	$1,000 00	$40 00
One bond New York Central & Hudson River Railroad debenture 4s, at	930 00	1,000 00	40 00
One bond New York Central & Hudson River Railroad debenture 3½s, at	870 00	1,000 00	17 50
Two bonds Metropolitan Street Railway of Kansas City 5s, at $950,	1,900 00	2,000 00	90 00
Three bonds Pacific Telephone and Telegraph Company 5s, at $990,	2,970 00	3,000 00	150 00
One bond Western Electric Company 5s, at	1,000 00	1,000 00	50 00
Boston & Albany Railroad stocks, 3⅝ shares, at $187,	677 88	362 50	31 68
Amherst Savings Bank, deposit,	72 75	72 75	3 06
Electric Securities Company bonds, 1⁹/₅₀, at $1,000,	1,121 00	1,180 00	59 00
Electric Securities Company bonds, 1⁹/₅₀, at $1,000 changing serial,	–	–	41 30
Kansas City Street Railway 5½s,	–	–	110 00
New York Central & Hudson River,	–	–	20 00
New York Central & Hudson River rights,	–	–	5 00
	$10,451 63	$10,615 25	$657 54
Unexpended balance Dec. 1, 1915,	–	–	899 77
	–	–	1,557 31
Disbursements for fiscal year ending Nov. 30, 1916,	–	–	176 90
Cash on hand Nov. 30, 1916,	–	–	$1,380 41

Mary Robinson Fund.

Amherst Savings Bank,	$142 00	$142 00	$6 03
Boston & Albany Railroad stock, ⅜ share, at $187,	70 13	38 00	3 32
Electric Securities Company bonds, ⁴¹/₅₀ share, at $1,000,	779 00	820 00	41 00
Electric Securities Company bonds, ⁴¹/₅₀ share, at $1,000, changing for later serial number,	–	–	28 70
	$991 13	$1,000 00	$79 05
Unexpended balance Dec. 1, 1915,	–	–	59 63
Cash on hand Nov. 30, 1916,	–	–	$138 68

Grinnell Prize Fund.

Ten shares New York Central & Hudson River Railroad stock, at $102,	$1,020 00	$1,000 00	$50 00
Unexpended balance Dec. 1, 1915,	–	–	195 74
	$1,020 00	$1,000 00	$245 74
Disbursements for prizes,	–	–	50 00
Cash on hand Nov. 30, 1916,	–	–	$195 74

Gassett Scholarship Fund.

One bond New York Central & Hudson River Railroad debenture 4s,	$930 00	$1,000 00	$40 00
Amherst Savings Bank, deposit,	11 64	11 64	46
	$941 64	$1,011 64	$40 46
Unexpended balance Dec. 1, 1915,	–	–	142 31
Cash on hand Nov. 30, 1916,	–	–	$182 77

SPECIAL FUNDS — *Concluded.*

Massachusetts Agricultural College (Investment).

		Market Value Dec. 1, 1916.	Par Value.	Income.
One share New York Central & Hudson River Railroad stock,		$102 00	$100 00	$5 00
Unexpended balance Dec. 1, 1915,		–	–	75 45
Cash on hand Nov. 30, 1916,		–	–	$80 45

Danforth Keyes Bangs Fund.

Two bonds Pacific Telephone and Telegraph Company 5s, at $990,		$1,980 00	$2,000 00	$100 00
Two bonds Union Electric Light and Power Company 5s, at $980,		1,960 00	2,000 00	100 00
Two bonds American Telephone and Telegraph Company 4s, at $910,		1,820 00	2,000 00	80 00
Interest from student loans,		–	–	42 63
		$5,760 00	$6,000 00	$322 63
Unexpended balance Dec. 1, 1915,		–	–	671 62
		–	–	$994 25
Total loans made to students during fiscal year,	$1,345 00			
Cash received on account of student loans,	1,351 00			
Excess over loans mad to students,		. . . .	. . . .	6 00
Cash on hand Nov. 30, 1916,		–	–	$1,000 25

John C. Cutter Fund.

One bond Pacific Telephone and Telegraph Company 5s,	$990 00	$1,000 00	$50 00
Unexpended balance Dec. 1, 1915,	–	–	47 84
	$990 00	$1,000 00	$97 84
Disbursements for fiscal year to date,	–	–	29 67
Cash on hand Nov. 30, 1916,	–	–	$68 17

William R. Sessions Fund.

One bond New York Central & Hudson River Railroad stock 6s,		$555 00	$500 00	$30 00
Amherst Savings Bank, deposit,		4,500 00	4,500 00	146 25
Disbursements for fiscal year to date,	$126 09	$5,055 00	$5,000 00	$176 25
Refund for fiscal year to date,	35 40	–	–	90 69
		–	–	$85 56
Cash on hand Nov. 30, 1915,		–	–	15 00
Cash on hand Nov. 30, 1916,		–	–	$100 56

Alvord Dairy Scholarship Fund.

Amherst Savings Bank, deposit,		$4,000 00	$4,000 00	$170 00
Overdraft Dec. 1, 1915,	$600 00	–	–	–
Less amount of receipts,	170 00	–	–	–
Overdraft Nov. 30, 1916,		–	–	–$430 00

Summary of Balances on Hand of the Income from Funds held in Trust by the Massachusetts Agricultural College.

Burnham emergency,	$500 55
Endowed labor fund,	537 04
Whiting Street scholarship fund,	239 18
Hills fund,	1,380 41
Mary Robinson fund,	138 68
Grinnell prize fund,	195 74
Gassett scholarship fund,	182 77
Massachusetts Agricultural College investment fund,	80 45
Danforth Keyes Bangs fund,	1,000 25
John C. Cutter fund,	68 17
Willam R. Sessions fund,	100 56
	$4,423 80
Alvord dairy scholarship fund overdraft,	430 00
	$3,993 80

I hereby certify that I have this day examined the Massachusetts Agricultural College account, as reported by the Treasurer, Fred C. Kenney, for the year ending Nov. 30, 1916. All bonds and investments are as represented in the treasurer's report. All disbursements are properly vouched for, and all cash balances are found to be correct.

CHARLES A. GLEASON,
Auditor.

Dec. 18, 1916.

History of Special Funds.

Burnham emergency fund: —

A bequest of $5,000 from T. O. H. P. Burnham of Boston, made without any conditions. The trustees of the college directed that $1,000 of this fund should be used in the purchase of the Newell land and Goessmann library. The fund now shows an investment of $4,000 00

Library fund: —

The library of the college at the present time contains 52,928 volumes. The income from the fund raised by the alumni and others is devoted to its increase, and additions are made from time to time as the needs of the different departments require. Dec. 27, 1883, William Knowlton gave $2,000; Jan. 1, 1894, Charles L. Flint gave $1,000; in 1887, Elizur Smith of Lee, Mass., gave $1,215. These were the largest bequests, and now amount to 10,000 00

Endowed labor fund: —

Gift of a friend of the college in 1901, income of which is be be used for the assistance of needy and deserving students, 5,000 00

Whiting Street scholarship: —

Gift of Whiting Street of Northampton, for no special purpose, but to be invested and the income used. This fund is now used exclusively for scholarship, ... 1,000 00

Hills fund: —	
Gift of Leonard M. and Henry F. Hills of Amherst, Mass., in 1867, to establish and maintain a botanic garden,	$10,000 00
Mary Robinson fund: —	
Gift of Miss Mary Robinson of Medfield, in 1874, for scholarship,	1,000 00
Grinnell prize fund: —	
Gift of Hon. Wm. Claflin, to be known as the Grinnell agricultural prize, to be given to the two members of the graduating class who may pass the best oral and written examination in theory and practice of agriculture, given in honor of George B. Grinnell of New York,	1,000 00
Gassett scholarship fund: —	
Gift of Henry Gassett of Boston, the income to be used for scholarship,	1,000 00
Massachusetts Agricultural College investment fund: —	
Investment made by vote of trustees in 1893 to purchase one share of New York Central & Hudson River Railroad stock. The income from this fund has been allowed to accumulate,	100 00
Danforth Keyes Bangs fund: —	
Gift of Louisa A. Baker of Amherst, Mass., April 14, 1909, the income thereof to be used annually in aiding poor, industrious and deserving students to obtain an education in said college,	6,000 00
John C. Cutter fund: —	
Gift of Dr. John C. Cutter of Worcester, Mass., an alumnus of the college, who died in August, 1909, to be invested by the trustees, and the income to be annually used for the purchase of books on hygiene,	1,000 00
Alvord dairy scholarship fund: —	
Gift of Henry E. Alvord, who was the first instructor in military tactics, 1869–71, and a professor of agriculture, 1885–87, at this institution. The income of this fund is to be applied to the support of any worthy student of said college, graduate or post-graduate, who may be making a specialty of the study of dairy husbandry (broadly considered), with the intention of becoming an investigator, teacher or special practitioner in connection with the dairy industry, provided that no benefits arising from such fund shall at any time be applied to any person who then uses tobacco in any form or fermented or spirituous beverages, or is known to have done so within one year next preceding,	4,000 00

William R. Sessions fund: —

In accordance with the request of my deceased wife, Clara Markham Sessions, made in her last will, I bequeath to the trustees of the Massachusetts Agricultural College. Amherst, Mass., the sum of $5,000, it being the amount received by me from the estate of the said Clara Markham Sessions. The said $5,000 to be kept by the said trustees a perpetual fund, the income from which shall be for the use of the Massachusetts Agricultural College; and according to the further request of my deceased wife, made in her last will, this is to be known as the William R. Sessions fund, and is to be a memorial of William R. Sessions; and it is my special request that the said trustees shall make record of the fact that this fund came from the estate of my deceased wife, Clara Markham Sessions, in accordance with her request made in her last will, . . $5,000 00

$49,100 00

PRIZES.

Animal husbandry. The F. Lothrup Ames prize, given by F. Lothrup Ames, Langwater Farms, North Easton, Mass., consisting of $150 a year, offered for a period of five years, to be given to the three students standing highest in the work of advanced live stock judging, and to be used in defraying their expenses incurred by participation in the students' judging contest at the National Dairy Show, Chicago. Given in May, 1912, available first in autumn of 1912, and for the four succeeding years, ... $150 00

FRED C. KENNEY,

Treasurer.

THE M. A. C. BULLETIN

AMHERST, MASS.

Vol. IX. No. I. **January, 1917**

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CATALOGUE

OF THE

MASSACHUSETTS AGRICULTURAL COLLEGE,

1916-1917.

FIFTY-FOURTH ANNUAL REPORT.

PART II.

BOSTON:
WRIGHT & POTTER PRINTING CO., STATE PRINTERS,
32 DERNE STREET.
1917.

Without excluding other scientific and classical studies, and including military tactics, to teach such branches of learning as are related to agriculture and mechanic arts in such manner as the legislatures of the states may respectively prescribe, in order to promote the liberal and practical education of the industrial classes in the several pursuits and professions of life. — *Act of Congress, July 2, 1862.*

MASSACHUSETTS AGRICULTURAL COLLEGE,

AMHERST.

CATALOGUE, 1916-1917.

BOSTON:
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32 DERNE STREET.
1917.

Publication of this Document
approved by the
Supervisor of Administration.

The Commonwealth of Massachusetts.

Massachusetts Agricultural College,
Amherst, Dec. 1, 1916.

To His Excellency Samuel W. McCall.

Sir: — On behalf of the trustees of the Massachusetts Agricultural College I have the honor to transmit herewith, to Your Excellency and the Honorable Council, Part II. of the fifty-fourth annual report of the trustees, this being the catalogue of the college.

I am, very respectfully, your obedient servant,

KENYON L. BUTTERFIELD,
President.

THE MASSACHUSETTS AGRICULTURAL COLLEGE.

This issue of the catalogue represents the status of the college for the current college year, with provisional announcement of courses of study and other matters for the year to follow. When deemed necessary, additional announcements are made in a supplementary bulletin, published in the spring.

The college reserves, for itself and its departments, the right to withdraw or change the announcements made in its catalogue. Special publication will be made should it become necessary on account of important changes.

Calendar.

1917-18.

Regular Courses.

1917.

January 2, 7.30 A.M., ...	Winter term begins; chapel.
February 22, Thursday afternoon, . . .	Half holiday, Washington's Birthday.
March 23, Friday, 5 P.M., ...	Winter term ends.
April 2, Monday, 12.40 P.M., . . .	Spring term begins; chapel.
April 19, Thursday afternoon, . . .	Half holiday, Patriots' Day.
May 30, Wednesday, ...	Holiday, Memorial Day.
June 23–27, Saturday–Wednesday, . .	Commencement.
June 27, Wednesday, ...	Spring term ends.
June 28–30, Thursday–Saturday, . . .	Entrance examinations.
July 2, Monday, ...	Summer term begins.
September 14, Friday, ...	Summer term ends.
September 12–15, Wednesday–Saturday, .	Entrance examinations.
September 19, Wednesday, 1.30 P.M., . .	Fall term begins; chapel.
October 12, Friday afternoon, . . .	Half holiday, Columbus Day.
November 28, Wednesday, 12 M.–Friday, November 30, 1 P.M., ...	Thanksgiving recess.
December 21, Friday, 5 P.M., . . .	Fall term ends.
December 31, Monday, 12.40 P.M., . .	Winter term begins; chapel.

1918.

February 22, Friday afternoon, . . .	Half holiday, Washington's Birthday.
March 22, Friday, 5 P.M..	Winter term ends.
April 1, Monday, 12.40 P.M., ...	Spring term begins; chapel.
April 19, Friday afternoon, ...	Half holiday, Patriot's Day.
May 30, Thursday, ...	Holiday, Memorial Day.
June 22–26, Saturday–Wednesday, . .	Commencement.
June 26, Wednesday, ...	Spring term ends.
June 27–29, Thursday–Saturday, . . .	Entrance examinations.
July 1, Monday, ...	Summer term begins.
September 18–21, Wednesday–Saturday, .	Entrance examinations.
September 20, Friday, ...	Summer term ends.
September 25, Wednesday, 1.30 P.M., . .	Fall term begins; chapel.

MASSACHUSETTS AGRICULTURAL COLLEGE.

HISTORY. — The Massachusetts Agricultural College was among the first of those organized under the national land grant act of 1862. This act granted public lands to the several States and Territories, the funds realized from the sale of which should be used to establish colleges of agriculture and mechanic arts; the bill was framed by the late Senator Justin Smith Morrill of Vermont. The Legislature of Massachusetts has granted money for the erection of nearly all the buildings now on the grounds, and makes annual appropriations for the maintenance of the college.

The college was incorporated in 1863, and on the 2d of October, 1867, was formally opened to its first class of students. At that time four buildings had been erected, and there were four regular instructors employed by the institution. In 1882 the State located its agricultural experiment station on the grounds of the college. Later, after the Federal law was passed granting financial aid to experiment stations, the Massachusetts Agricultural Experiment Station was consolidated with the Federal station, and subsequently the whole was incorporated with the college.

COURSES. — The college offers an education without tuition fee to any student who is a resident of Massachusetts and who meets the requirements for admission. Women are admitted on the same basis as are men. Students who are not residents of Massachusetts are required to pay a nominal tuition fee. The four-year[1] course leads to the degree of bachelor of science, and the graduate school offers advanced courses leading to the degrees of master of science, doctor of philosophy and master of agriculture. The winter school of ten weeks, for admission to which no scholastic requirements are made, is held each winter, beginning early in January. There are other short courses at the college, such as the beekeepers' course and summer school. Various forms of extension teaching are carried on away from the college, such as correspondence courses, traveling schools, educational exhibits, lecture courses, demonstrations and circulating libraries.

PURPOSE OF THE COLLEGE. — The chief purpose of the college is to prepare men and women for the agricultural vocations. In this statement the term "agricultural vocations" is used in its broadest sense. Courses are offered which give efficient training in various agricultural pursuits, such as general farming, dairying, management of estates, poultry husbandry, fruit growing, market gardening, landscape gardening and forestry. Students are also fitted for positions in institutions designed for investigation in many sciences underlying the great agricultural industry, for teaching in agricultural col-

[1] Twenty-seven teaching departments offer instruction in agriculture, horticulture, sciences, the humanities and rural social science. A system of major courses permits a student to elect major work in 1 of 17 departments, specializing in that and allied subjects for a period of two years.

leges and high schools, for scientific experts in chemistry, entomology, botany and microbiology and for business operations having connection with practical agriculture.

Though the agricultural vocations are thus the chief concern of the college, students also find the course one that fits them admirably for pursuits in which the sciences, particularly chemistry, botany and zoölogy, are an essential preparation. Still other students find the course a desirable education, without regard to future occupation. The course of study is designed to give a student a general college education, and in addition to make it possible for him to specialize in any department in which a major course is offered.

Location and Equipment. — The agricultural college is located in the town of Amherst. The grounds comprise more than 600 acres, lying about a mile north of the village center. The equipment of the college, both in buildings and facilities for instruction, is excellent. Amherst is about 98 miles from Boston, and may be reached over the Central Massachusetts division of the Boston & Maine Railroad, or by way of the Central Vermont Railroad. Electric car lines connect Amherst with Northampton, Holyoke and Springfield.

The Massachusetts Agricultural Experiment Station.

Massachusetts provided for the establishment of an agricultural experiment station in 1882. This station, though on the college grounds and supported by the State, was then without organic connection with the college. Under an act of Congress, passed in 1887, an agricultural experiment station was established as a department of the college, and was supported by the general government. For a time, therefore, Massachusetts had two experiment stations at the college. In 1894 these were combined, and the station reorganized as a department of the college. It is now supported by funds from both the State and the general government. In 1906 the general government largely increased its support of experiment stations, on condition, however, that the money thus provided should be used only for research. The station now receives about one-half of its support from the State.

The station is under the direct supervision of the Board of Trustees. The chief officer is the director, who is responsible to the president and to a committee of the Board. The station is organized into a number of departments, all co-operating toward the betterment of agriculture. In most cases the heads of the station departments are heads of corresponding departments in the college. The work of the station takes three directions; namely, control work, experimentation and investigation. The station publishes numerous bulletins and two annual reports, one scientific, the other for practical farmers and for general distribution. These publications, conveying information as to results of experiments, are free, and circulate extensively, the mailing list containing some 20,000 addresses.

The Corporation.

ORGANIZATION OF 1917.

Members of the Corporation.

	TERM EXPIRES
Charles H. Preston of Danvers,	1918
Frank A. Hosmer of Amherst,	1918
Davis R. Dewey of Cambridge,	1919
John F. Gannon of Worcester,	1919
Arthur G. Pollard of Lowell,	1920
George H. Ellis of West Newton,	1920
Elmer D. Howe of Marlborough,	1921
Edmund Mortimer of Grafton,	1921
Nathaniel I. Bowditch of Framingham,	1922
William Wheeler of Concord,	1922
Charles A. Gleason of New Braintree,	1923
James F. Bacon of Boston,	1923
Frank Gerrett of Greenfield,	1924
Harold L. Frost of Arlington,	1924

Members Ex Officio.

His Excellency Governor Samuel W. McCall, *President of the Corporation.*
Kenyon L. Butterfield, *President of the College.*
Payson Smith, *State Commissioner of Education.*
Wilfrid Wheeler, *Secretary of the State Board of Agriculture.*

Officers of the Corporation.

His Excellency Governor Samuel W. McCall of Boston, *President.*
Charles A. Gleason of New Braintree, *Vice-President.*
Wilfrid Wheeler of Concord, *Secretary.*
Fred C. Kenney of Amherst, *Treasurer.*
Charles A. Gleason of New Braintree, *Auditor.*

Standing Committees of the Corporation.[1]

Committee on Finance.

Charles A. Gleason, *Chairman.*
George H. Ellis.
Nathaniel I. Bowditch.
Arthur G. Pollard.
Frank A. Hosmer.
Edmund Mortimer.

Committee on Course of Study and Faculty.

William Wheeler, *Chairman.*
Frank A. Hosmer.
Elmer D. Howe.
Payson Smith.
Davis R. Dewey.
John F. Gannon.
James F. Bacon.

Committee on Farm.

Nathaniel I. Bowditch, *Chairman.*
Frank Gerrett.
George H. Ellis.
Edmund Mortimer.

[1] The president of the college is ex-officio member of each standing committee.

Committee on Horticulture.

HAROLD L. FROST, *Chairman.*
CHARLES A. GLEASON.
ELMER D. HOWE.
WILFRID WHEELER.

Committee on Experiment Department.[1]

CHARLES H. PRESTON, *Chairman.*
WILFRID WHEELER.
ARTHUR G. POLLARD.
HAROLD L. FROST.
EDMUND MORTIMER.

Committee on Buildings and Arrangement of Grounds.

FRANK GERRETT, *Chairman.*
WILLIAM WHEELER.
CHARLES H. PRESTON.
GEORGE H. ELLIS.
JAMES F. BACON.

Committee on Extension Service.

ELMER D. HOWE, *Chairman.*
GEORGE H. ELLIS.
HAROLD L. FROST.
DAVIS R. DEWEY.
WILFRID WHEELER.
JOHN F. GANNON.

Examining Committee of Overseers from the State Board of Agriculture.

JOHN BURSLEY of West Barnstable.
FRANK P. NEWKIRK of Easthampton.
WILLIAM E. PATRICK of Warren.
JOHN J. ERWIN of Wayland.
CHARLES W. FREEHAN of Great Barrington.

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[1] The director of the experiment station is a member of the committee on experiment department, without vote.

Officers of the Institution.

[The names of the faculty are arranged in groups according to rank. Within these groups, the order depends upon seniority of service in the College, not upon seniority of appointment to the position now held.]

THE FACULTY.

Kenyon L. Butterfield, A.M., LL.D., ... President's House.
President of the College and Head of Division of Rural Social Science.

Charles H. Fernald, Ph.D., ... 3 Hallock Street.
Honorary Director of the Graduate School.

Edward M. Lewis, A.M., ... 19 Lincoln Avenue.
Dean of the College and Professor of Languages and Literature.

Fred C. Kenney, ... Mount Pleasant.
Treasurer of the College.

William P. Brooks, Ph.D., ... 6 Farview Way.
Director of the Experiment Station and Lecturer on Soil Fertility.

William D. Hurd, M.Agr., ... 46 Amity Street.
Director of the Extension Service and Supervisor of Short Courses.

Charles E. Marshall, Ph.D., ... 44 Sunset Avenue.
Director of the Graduate School and Professor of Microbiology.

Frank A. Waugh, M.Sc., ... Campus.
Head of Division of Horticulture and Professor of Landscape Gardening.

James A. Foord,[1] M.Sc.Agr., ... 54 Lincoln Avenue.
Head of Division of Agriculture and Professor of Farm Administration.

Robert J. Sprague, Ph.D., ... Mount Pleasant.
Head of Division of Humanities and Professor of Economics and Sociology.

Joseph B. Lindsey, Ph.D., ... 47 Lincoln Avenue.
Goessmann Professor of Chemistry.

Charles Wellington, Ph.D., ... 34 Amity Street.
Professor of Chemistry.

James B. Paige, B.Sc., D.V.S., ... 42 Lincoln Avenue.
Professor of Veterinary Science.

Philip B. Hasbrouck, B.Sc., ... 130 Pleasant Street.
Registrar of the College and Professor of Physics.

John E. Ostrander, A.M., C.E., ... 33 North Prospect Street.
Professor of Mathematics and Civil Engineering.

Henry T. Fernald, Ph.D., ... 44 Amity Street.
Professor of Entomology, Chairman of Division of Science.

A. Vincent Osmun, M.Sc., ... 5 Kendrick Place.
Professor of Botany.

William R. Hart, A.M., LL.B., ... 97 Pleasant Street.
Professor of Agricultural Education.

Fred C. Sears,[2] M.Sc., ... Mount Pleasant.
Professor of Pomology.

William P. B. Lockwood, M.Sc., ... 34 North Prospect Street.
Professor of Dairying.

Alexander E. Cance, Ph.D., ... 9 Fearing Street.
Professor of Agricultural Economics.

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[1] On leave, Jan. 15, 1917–Jan. 14, 1918. [2] On leave, first term, 1916–17.

JOSEPH S. CHAMBERLAIN, Ph.D., Professor of Organic and Agricultural Chemistry.	Mount Pleasant.
JOHN C. GRAHAM, B.Sc.Agr., Professor of Poultry Husbandry.	Lincoln Avenue.
G. CHESTER CRAMPTON, Ph.D., Professor of Insect Morphology.	10 Allen Street.
CHARLES A. PETERS, Ph.D., Professor of Inorganic and Soil Chemistry.	2 Sunset Avenue.
CURRY S. HICKS, B.Pd., Professor of Physical Education and Hygiene.	8 Allen Street.
WILLIAM D. CLARK, A.B., M.F., Professor of Forestry.	3 Mount Pleasant.
ERNEST ANDERSON, Ph.D., Professor of General and Physical Chemistry.	3 Phillips Street.
CHRISTIAN I. GUNNESS, B.Sc., Professor of Rural Engineering.	105 Butterfield Road.
HENRY W. FLEET, Captain, U. S. A., Professor of Military Science and Tactics.	5 Phillips Street.
HAROLD F. TOMPSON, B.Sc., Professor of Market Gardening.	10 Temple Street, Arlington.
JOHN PHELAN, A.M., Professor of Rural Sociology.	29 Northampton Road.
JOHN C. McNUTT, B.Sc.Agr., Professor of Animal Husbandry.	33 East Pleasant Street.
CLARENCE E. GORDON, Ph.D., Associate Professor of Zoölogy and Geology.	38 Lincoln Avenue.
ROBERT W. NEAL, A.M., Associate Professor of English.	15 Spring Street.
EDGAR L. ASHLEY, A.M., Associate Professor of German.	24 Pleasant Street.
ALEXANDER A. MACKIMMIE, A.M., Associate Professor of French.	Pine Street, North Amherst.
BURTON N. GATES, Ph.D., Associate Professor of Beekeeping.	42 Lincoln Avenue.
GEORGE E. GAGE, Ph.D., Associate Professor of Animal Pathology.	27 Sunset Avenue.
WALTER W. CHENOWETH, A.B., M.Sc., Associate Professor of Pomology.	North Amherst.
F. H. HESSELINK VAN SUCHTELEN, Ph.D., Associate Professor of Microbiology.	30 North Prospect Street.
ARNO H. NEHRLING, Associate Professor of Floriculture.	5 Kendrick Place.
PAUL J. ANDERSON, Ph.D., Associate Professor of Botany.	24 Pleasant Street.
RALPH J. WATTS, B.Sc., Secretary of the College.	101 Butterfield Road.
CHARLES R. GREEN, B.Agr., Librarian.	Mount Pleasant.
C. ROBERT DUNCAN, B.Sc., C.E., Assistant Professor of Mathematics.	23 Lincoln Avenue.
ARTHUR K. HARRISON, Assistant Professor of Landscape Gardening.	8 Allen Street.
ELVIN L. QUAIFE, B.Sc.Agr., Assistant Professor of Animal Husbandry.	103 Butterfield Road.
WILLIAM L. MACHMER, A.M., M.E., Assistant Professor of Mathematics.	3 Kendrick Place.
WALTER E. PRINCE, Ph.B., A.M., Assistant Professor of English.	4 Kendrick Place.
HAROLD E. ROBBINS, B.Sc., A.M., Assistant Professor of Physics.	4 Nutting Avenue.
ORTON L. CLARK, B.Sc., Assistant Professor of Botany.	16 College Street.
LOYAL F. PAYNE, B.Sc., Assistant Professor of Poultry Husbandry.	12 Chestnut Street.

Earl Jones, M.Sc., Assistant Professor of Agronomy.	3 Phillips Street.
Charles H. Thompson, M.Sc., Assistant Professor of Horticulture.	77 South Pleasant Street.
Andrew S. Thomson, Ph.B., A.M., Assistant Professor of Market Gardening.	10½ Kellogg Avenue.
Orville A. Jamison, M.Sc., Assistant Professor of Dairying.	7 East Pleasant Street.
John T. Wheeler, B.Sc.Agr., Assistant Professor of Horticulture.	13 Fearing Street.
Charles H. Patterson, A.B., A.M., Assistant Professor of English.	54 Pleasant Street.
Frank W. Rane, M.F., Lecturer in Forestry.	Boston.
Helena T. Goessmann, M.Ph., Instructor in English.	13 Main Street.
William L. Harmount, A.B., Instructor in French.	86 Pleasant Street.
Arthur N. Julian, A.B., Instructor in German.	Farview Way.
Frederick A. McLaughlin,[1] B.Sc., Instructor in Botany.	24 Pleasant Street.
Samuel Coons, Instructor in Dairying.	2 McClellan Street.
Harold M. Gore, B.Sc., Instructor in Physical Education.	8 Allen Street.
Burt A. Hazeltine, B.Sc., Instructor in Mathematics.	4 North Prospect Street.
William S. Regan, Ph.D., Instructor in Entomology.	86 Pleasant Street.
Frank P. Rand, A.M., Instructor in English.	North Amherst.
Arao Itano, Ph.D., Instructor in Microbiology.	7 East Pleasant Street.
Walter M. Peacock, M.S.Agr., Instructor in Farm Management.	24 Pleasant Street.
George W. Martin, M.Sc., Instructor in Botany.	7 Phillips Street.
Harry D. Drain, B.Sc.Agr., Instructor in Dairying.	24 Pleasant Street.
Stanley C. Ball, Ph.D., Instructor in Zoölogy.	45 Amity Street.
Ralph M. Rutledge, M.Sc., Instructor in Agricultural Economics.	13 Fearing Street.
Everett H. Rucker, B.Sc., A.M., Instructor in Poultry Husbandry.	5 School Street.
Charles H. Gould, B.Sc., Field Agent.	4 Nutting Avenue.
William J. Fitzmaurice, Assistant in Physical Education.	– –
Paul Serex, Jr., M.Sc., Assistant in Chemistry.	116 Pleasant Street.
Frederick G. Merkle, B.Sc., Assistant in Agronomy.	East Street.
Harry C. Thompson, B.Sc., Assistant in Physics.	16 North Prospect Street.
Philip W. Payne, A.B.,[2] Assistant in English.	5 Kendrick Place.
Joseph Novitski,[2] Assistant in Rural Sociology.	Pelham Road.

[1] On leave, 1916–17. [2] Part time.

GRADUATE ASSISTANTS.

ROBERT P. ARMSTRONG, M.Sc., ... Phi Sigma Kappa House.
Department of Pomology, Experiment Station.
ROY C. AVERY, B.Sc., ... 15 Spring Street.
Industrial Tests, Experiment Station.
PAUL BEEBE, A.B., ... 45 Pleasant Street.
Department of Chemistry.
J. STANLEY COBB, B.Sc., ... 24 Pleasant Street.
Department of Agronomy.
SAMUAL H. DE VAULT,[1] M.A., ... 9 Fearing Street.
Department of Agricultural Economics, Experiment Station.
WILLIAM L. DORAN,[2] B.Sc., ... Clark Hall.
Department of Botany.
ERNEST E. FISH, B.Sc., ... 24 Pleasant Street.
Department of Animal Husbandry.
EGERTON G. HOOD, B.Sc., ... 15 Spring Street.
Industrial Tests, Experiment Station.
HAROLD KELLEY, B.Sc., ... 116 Pleasant Street.
Department of Chemistry.
RALPH L. MACNEIL, B.Sc., ... 5 Spring Street.
Department of Chemistry.
SATWAJI G. MUTKEKAR, B.Agr., ... Farview Way.
Industrial Tests, Experiment Station.
GERALD E. PERRY, B.Sc., ... 17 Amity Street.
Department of Chemistry.
ARTHUR L. PRINCE, A.B., ... 4 Kendrick Place.
Department of Chemistry.
JAMES A. PURINGTON, B.Sc., ... 116 Pleasant Street.
Department of Agronomy.
GEORGE B. RAY, B.Sc., ... East Pleasant Street.
Department of Microbiology.
IRVING C. ROOT, B.Sc., ... 24 Pleasant Street.
Department of Landscape Gardening.
LLOYD L. STEWART, B.Sc., ... 18 Nutting Avenue.
Department of Poultry Husbandry.
STUART C. VINAL, B.Sc., ... 112 Pleasant Street.
Department of Entomology, Experiment Station.
DONALD WHITE, B.A., ... 24 Pleasant Street.
Department of Botany.
CARRICK E. WILDON, B.Sc., ... 66 Pleasant Street.
Department of Floriculture.
ELWIN G. WOOD, B.Sc., ... Wilder Hall.
Department of Pomology.

THE EXPERIMENT STATION STAFF.

ADMINISTRATION.

WILLIAM P. BROOKS, Ph.D., ... 6 Farview Way.
Director.
JOSEPH B. LINDSEY, Ph.D., ... 47 Lincoln Avenue.
Vice-Director.
FRED C. KENNEY, ... Mount Pleasant.
Treasurer.
CHARLES R. GREEN, B.Agr., ... Mount Pleasant.
Librarian.

DEPARTMENT OF AGRICULTURAL ECONOMICS.

ALEXANDER E. CANCE, Ph.D., ... 9 Fearing Street.
In charge of Department.

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[1] Services began Jan. 9, 1917. [2] Resigned, to take effect Nov. 20, 1916.

Department of Agriculture.

William P. Brooks, Ph.D., ... 6 Farview Way.
Agriculturist.
Henry J. Franklin, Ph.D., ... Wareham.
In charge of Cranberry Investigation.
Edwin F. Gaskill, B.Sc., ... North Pleasant Street.
Assistant Agriculturist.
Robert L. Coffin, ... 19 Phillips Street.
Assistant.

Department of Botany and Vegetable Pathology.

A. Vincent Osmun, M.Sc., ... 5 Kendrick Place.
Botanist.
George H. Chapman, Ph.D., ... Fearing Street.
Research Physiologist.
Paul J. Anderson, Ph.D., ... 24 Pleasant Street.
Associate Plant Pathologist.
Orton L. Clark, B.Sc., ... 16 College Street.
Assistant Plant Physiologist.

Department of Entomology.

Henry T. Fernald, Ph.D., ... 44 Amity Street.
Entomologist.
Burton N. Gates, Ph.D., ... 42 Lincoln Avenue.
Apiarist.
Arthur I. Bourne, A.B., ... 12 East Pleasant Street.
Assistant Entomologist.

Department of Plant and Animal Chemistry.

Joseph B. Lindsey, Ph.D., ... 47 Lincoln Avenue.
Chemist.
Edward B. Holland, Ph.D., ... 28 North Prospect Street.
Associate Chemist in charge of Research Division.
Fred W. Morse, M.Sc., ... 40 Pleasant Street.
Research Chemist.
Henri D. Haskins, B.Sc., ... 14 Amity Street.
In charge of Fertilizer Division.
Philip H. Smith, M.Sc., ... 102 Main Street.
In charge of Feed and Dairy Division.
Lewell S. Walker, B.Sc., ... 19 Phillips Street.
Assistant.
Rudolph W. Ruprecht,[1] Ph.D., ... 24 Pleasant Street.
Assistant.
Carleton P. Jones, M.Sc., ... Bank Block.
Assistant.
Carlos L. Beals, M.Sc., ... 4 Kendrick Place.
Assistant.
James P. Buckley, B.Sc., ... 29 Lincoln Avenue.
Assistant.
Windom A. Allen, B.Sc., ... 24 Pleasant Street.
Assistant.
John B. Smith,[2] B.Sc., ... North Prospect Street.
Assistant.
Robert S. Scull,[3] B.Sc., ... Mount Pleasant.
Assistant.
James T. Howard, ... 46 Pleasant Street.
Collector.
Harry L. Allen, ... 89 Main Street.
Assistant.
James R. Alcock, ... North Amherst.
Assistant.

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[1] Resigned Nov. 30, 1916.
[2] Services began Oct. 1, 1917.
[3] Services began Feb. 1, 1917.

DEPARTMENT OF HORTICULTURE.

FRANK A. WAUGH, M.Sc., ... Campus.
Horticulturist.
FRED C. SEARS,[1] M.Sc., ... Mount Pleasant.
Pomologist.
JACOB K. SHAW, Ph.D., ... 5 Farview Way.
Research Pomologist.

DEPARTMENT OF METEOROLOGY.

JOHN E. OSTRANDER, A.M., C.E., ... 33 North Prospect Street.
Meteorologist.

DEPARTMENT OF MICROBIOLOGY.

CHARLES E. MARSHALL, Ph.D., ... 44 Sunset Avenue.
In charge of Department.
F. H. HESSELINK VAN SUCHTELEN, Ph.D., ... 30 North Prospect Street.
Associate Professor of Microbiology.

DEPARTMENT OF POULTRY HUSBANDRY.

JOHN C. GRAHAM, B.Sc.Agr., ... Lincoln Avenue.
In charge of Department.
HUBERT D. GOODALE, Ph.D., ... North Amherst.
Research Biologist.

DEPARTMENT OF VETERINARY SCIENCE.

JAMES B. PAIGE, B.Sc., D.V.S., ... 42 Lincoln Avenue.
Veterinarian.
GEORGE E. GAGE, Ph.D., ... 27 Sunset Avenue.
Associate Professor of Animal Pathology.
JOHN B. LENTZ, A.B., V.M.D., ... 24 Pleasant Street.
Assistant in Veterinary Science.
ARNOLD P. STURTEVANT,[2] A.B., ... 41 Lincoln Avenue.
Assistant in Veterinary Science.

THE EXTENSION SERVICE STAFF.

WILLIAM D. HURD, M.Agr., ... 46 Amity Street.
Director of the Extension Service and Supervisor of Short Courses.
EARNEST D. WAID, B.Sc.Agr., ... 61 Amity Street.
Assistant Director.
SUMNER R. PARKER, B.Sc., ... 51 Amity Street.
Extension Professor of Rural Organization and County Agent Leader.
EZRA L. MORGAN, A.M., ... 2 Allen Street.
Extension Professor of Community Planning.
LAURA COMSTOCK, ... 84 Pleasant Street.
Extension Professor of Home Economics.
E. FARNHAM DAMON, B.Sc., ... Bank Block.
Extension Associate Professor of Agricultural Economics.
GEORGE L. FARLEY, M.Sc., ... 31 Lincoln Avenue.
Supervisor of Junior Extension Work.
ERWIN H. FORBUSH, ... 8 Nutting Avenue.
Supervisor of Correspondence Courses.
ETHEL H. NASH, ... 16 Nutting Avenue.
Extension Instructor in Agricultural Education.
ALFRED G. LUNN, B.Sc., ... North Amherst.
Extension Instructor in Poultry Husbandry.
ERIC N. BOLAND,[3] M.Sc., ... Bank Block.
Extension Instructor in charge of Boys' and Girls' Pig Club Work.
MARIE SAYLES, B.Sc., ... 79 Pleasant Street.
Extension Instructor in Home Economics.

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[1] On leave, first term, 1916–17.
[2] Resigned, to take effect Nov. 30, 1916.
[3] Resigned, to take effect Dec. 2, 1916.

WESLEY H. BRONSON, B.Sc., ... Lincoln Block.
Extension Instructor in Farm Demonstration.
WILLIAM F. TURNER, B.Sc., ... 37 Cottage Street.
Extension Instructor in Animal Husbandry.
FRANK A. C. SMITH, B.Sc., ... 24 Pleasant Street.
Extension Instructor in Civic Improvement.
AUSTIN D. KILHAM, B.Sc.Agr., ... 24 Pleasant Street.
Extension Instructor in Pomology.
VICTOR A. RICE,[1] B.Sc., ... 24 Pleasant Street.
Extension Instructor in charge of Pig Club Work.
ROSWELL W. HENNINGER,[2] . . . . 87 Pleasant Street.
Extension Instructor in charge of Poultry Club Work.

THE CLERICAL STAFF.

ELBERT L. ARNOLD, ... North Amherst.
Chief Clerk, Extension Service.
ELEANOR BARKER, ... 9 Phillips Street.
Clerk, Division of Horticulture.
ELEANOR F. BISHOP, ... 3 Spaulding Street.
Clerk, Treasurer's Office.
EVELYN BREWSTER, B.Sc., ... 9 Phillips Street.
Clerk, President's Office.
JOHN K. BROADFOOT, ... 7½ East Pleasant Street.
Cashier, Treasurer's Office.
MAUDE CHAMBERS,[3] . . . . 6 Allen Street.
Inventory Clerk, Treasurer's Office.
LENA V. CHAPMAN, ... 77 South Pleasant Street.
Library Assistant.
LUCIA G. CHURCH, ... North Amherst.
First Clerk, Experiment Station.
DORIS CLARK,[1] . . . . North Amherst.
Stenographer, Extension Service.
MARCELLA P. CURRY, B.Sc., ... Draper Hall.
Clerk, Department of Poultry Husbandry.
LALIA M. DAMON, ... 10 Nutting Avenue.
Cataloguer, Library.
LOUISE G. DAVIDSON, ... 7 Northampton Road.
Telephone Operator, Stockbridge Hall.
LLEWELYN L. DERBY, ... 81 Pleasant Street.
Assistant, Department of Physical Education.
HAZEL DEWAR, ... 6 Clifton Avenue.
Stenographer, Division of Agriculture.
MARION F. DONDALE, A.B., ... 101 Butterfield Road.
Clerk, Graduate School and Department of Microbiology.
F. ETHEL FELTON, A.B., ... 8 Allen Street.
Clerk, Director's Office, Experiment Station.
KATHERINE L. FENTON,[4] . . . . Northampton.
Stenographer, Department of Dairying.
LINA E. FISHER, ... 28 Pleasant Street.
Clerk, Department of Chemistry.
GRACE E. GALLOND, ... 28 Pleasant Street.
Clerk, Department of Dairying.
MARGARET T. GASKELL, ... 105 Main Street.
Stenographer, offices of Dean and Registrar.
LILLIAN M. GELINAS, ... 77 Pleasant Street.
Clerk, President's Office.
ALICE M. GILBERT,[5] . . . . 9 Phillips Street.
First Clerk, Division of Agriculture.
CORA B. GROVER, ... North Amherst.
Clerk, Director's Office, Extension Service.

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[1] Services began Dec. 4, 1916.
[2] Services began Jan. 1, 1917.
[3] Services began Nov. 1, 1916.
[4] Resigned Feb 13, 1917.
[5] Resigned Nov. 9, 1916.

MARION GUERTIN, Clerk, Department of Beekeeping.	20 Pleasant Street.
LILLIAN S. HADFIELD, Clerk, Extension Service.	9 Phillips Street.
LAURA W. HAGER, A.B., Clerk, Department of Agricultural Economics.	South Deerfield.
MARY G. HANIFIN,[1] Clerk, Division of Agriculture.	Northampton.
MARY E. HORTON, Clerk, Department of Rural Sociology.	79 Pleasant Street.
ALICE M. HOWARD, First Clerk, Experiment Station.	North Amherst.
LORIAN P. JEFFERSON, A.M., Research Secretary, Division of Rural Social Science.	84 Pleasant Street.
HELENA KEIBER, Stenographer, Extension Service.	50 Pleasant Street.
CLARENCE KENDALL,[2] Clerk, Extension Service.	Hadley.
ETHEL L. KENNEDY, Clerk, Extension Service.	9 Phillips Street.
HELEN MARTIN,[3] Stenographer, Department of Entomology.	19 South East Street.
IRENE A. MARTIN, Stenographer, Treasurer's Office.	19 South East Street.
REBECCA L. MELLOR, Clerk, Experiment Station.	10 Kellogg Avenue.
NELL C. MILTON, Stenographer, Division of Rural Social Science.	Draper Hall.
ELIZABETH E. MOONEY, Stenographer, Department of Poultry Husbandry.	Draper Hall.
GRACE B. NUTTING, Ph.B., Curator, Department of Botany.	North Amherst.
BRIDIE E. O'Donnell, Clerk, Department of Entomology.	Hadley.
HELEN C. POMEROY, Clerk, Department of Floriculture.	Draper Hall.
FRANCES POWERS,[4] Stenographer, Department of Dairying.	Lincoln Avenue.
VIVIAN ROY, Library Assistant.	5 McClellan Street.
EDNA M. SANDERS, Bookkeeper, Treasurer's Office.	Hadley.
MARY I. SHORES, Clerk, Dean's Office.	Bank Block.
ELSA SLATTERY,[5] Stenographer, Extension Service.	Northampton.
ETHELYN STREETER, Stenographer, Division of Horticulture.	South Deerfield.
FLORA E. TORREY, Clerk, Extension Service.	North Mt. Pleasant.
ETHEL M. TURNER, Library Assistant.	55 Pleasant Street.
OLIVE M. TURNER, B.Sc., Clerk, Registrar's Office.	22 Spaulding Street.
HENRIETTA L. WEBSTER, First Clerk, Treasurer's Office.	Draper Hall.
ELLEN L. WELCH,[6] Stenographer, Department of Botany.	17 Fearing Street.
AURELIA B. WENTWORTH, First Clerk, Division of Agriculture.	South Amherst.

[1] Services began Nov. 13, 1916.
[2] Services began Jan. 15, 1917.
[3] Services began Oct. 14, 1916.
[4] Services began Feb. 1, 1917.
[5] Resigned, to take effect Dec. 9, 1916.
[6] Services began Jan. 2, 1917.

STAFF OF OPERATING AND MAINTENANCE.

JOHN J. BARBER, Farm Superintendent.	Campus.
THOMAS BUTTERWORTH, Engineer.	6 Phillips Street.
JOHN L. BYARD, Superintendent of the Apiary.	21 Pleasant Street.
LAWRENCE S. DICKINSON, B.Sc., Superintendent of Grounds.	2 Farview Way.
CLARENCE A. JEWETT, Superintendent of Buildings.	112 Pleasant Street.
ORA L. KENNEDY, Manager of the Dining Hall.	Draper Hall.
JOHN J. LEE, Assistant to the Military Detail.	38 Cottage Street.
FLORENCE LEVENSALER, Resident Nurse.	Infirmary.
GEORGE F. PUSHEE, Shop Assistant, Rural Engineering.	21 Maple Ave., Northampton.
ALEXANDER SMART, Assistant to the Commandant.	39 East Pleasant Street.
NEWTON WALLACE,[1] Electrician.	Campus.
JAMES WHITING, Foreman, Department of Floriculture.	16 Hallock Street.

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[1] Retired Jan. 31, 1917.

Standing Committees of the Faculty.

1916–17.

Catalogue and Other Publications.

Associate Professor Neal.
Professor Lockwood.
Secretary Watts.

Commencement.

Dean Lewis.
Treasurer Kenney.
Captain Fleet.
Professor Peters.
Associate Professor Nehrling.
Secretary Watts.
Assistant Professor Robbins.

Course of Study.

President Butterfield.
Dean Lewis.
Professor Hart.
Professor Waugh.
Professor Foord.
Professor Sprague.
Professor Fernald.
Professor Ostrander.
Professor Marshall.
Professor Chamberlain.
Professor Cance.
Associate Professor Chenoweth.

Discipline (Advisory).

Dean Lewis.
Registrar Hasbrouck.
Professor Hicks.
Professor Phelan.
Associate Professor Mackimmie.

Employment.

Professor Sears.
Dean Lewis.
Treasurer Kenney.
Professor Lockwood.
Professor McNutt.
Secretary Watts.

Entrance Examinations and Admission.

Registrar Hasbrouck.
Dean Lewis.
Professor Osmun.
Professor Ernest Anderson.
Associate Professor Ashley.
Assistant Professor Duncan.
Mr. Rand.

Health and Sanitation.

Professor Marshall.
Treasurer Kenney.
Captain Fleet.
Professor Hicks.
Miss Comstock.

Library.

Professor Marshall.
Professor Sprague.
Professor Gunness.
Assistant Professor A. S. Thomson.
Mr. Green.

Schedule.

Professor Lockwood.
Professor Peters.
Assistant Professor Duncan.

Scholarship.

Dean Lewis.
Registrar Hasbrouck.
Professor Chamberlain.
Professor Ernest Anderson.
Associate Professor Mackimmie.
Assistant Professor Robbins.
Assistant Professor Machmer.
Mr. Rand.

Student Life.

President Butterfield.
Dean Lewis.
Treasurer Kenney.
Director Hurd.
Professor Chamberlain.
Professor Sprague.
Professor Hart.
Professor Crampton.
Professor Phelan.
Professor Lockwood.
Professor Ernest Anderson.
Professor Hicks.
Associate Professor Mackimmie.
Secretary Watts.
Associate Professor Paul J. Anderson.
Assistant Professor Harrison.
Assistant Professor Quaife.
Assistant Professor Machmer.
Assistant Professor A. S. Thomson.
Assistant Professor Robbins.

UNCLASSIFIED STUDENTS.

Dean LEWIS.
Professor WAUGH.
Professor FOORD.
Registrar HASBROUCK.
Assistant Professor MACHMER.

APPOINTED TO ATHLETIC BOARD.

Dean LEWIS.
Registrar HASBROUCK.
Professor OSMUN.

APPOINTED TO NON-ATHLETIC BOARD.

Professor LOCKWOOD.
Assistant Professor MACHMER.

THE COLLEGE.

ADMISSION.

A. Application for Admission.

All correspondence concerning admission should be addressed to the registrar.

Every applicant for admission to the college must be at least sixteen years old, and must present to the registrar proper testimonials of good character. Such testimonials, whenever possible, should come from the principal of the school at which the applicant has prepared for college. Candidates who desire to present themselves for examination in any subjects must make application to the college for such privilege at least one month before examination is desired. Blanks for such application may be obtained by addressing the registrar of the college. All entrance credentials must be in the hands of the registrar before the applicant can matriculate.

B. Modes of Admission.

Students are admitted to the freshman class either upon certificate or upon examination. No *diploma* from a secondary school will be accepted.

Certificates. — Certificates will be received from those schools in New England which have been approved by the New England College Entrance Certificate Board. Principals of schools in New England who desire the certificate privilege should address the secretary of the Board, Professor Frank W. Nicolson, Wesleyan University, Middletown, Conn. Certificates from schools outside of New England may be received if those schools are on the approved list of the leading colleges of the section in which the school in question is located.

The credentials of the Board of Regents of the State of New York are accepted as satisfying the entrance requirements of this college when offered subject for subject.

Certificates in order to be accepted must present at least three of the necessary fourteen credits. It is to be understood, however, that responsibility for certification in either elementary French, elementary German, English 1 or English 2, Latin A, Greek A or algebra must be assumed by one school, if the candidate has received his preparation in any one subject named above in more than one school. Subjects lacking on certificate (except for the permitted number of conditions) must be made up at the time of the examinations for admission.

Blank forms for certification — sent to principals or school superintendents only — may be obtained on application to the registrar of the college.

Examinations. — The examination in each subject may be oral or written, or both. The standard required for passing an examination for admission is 65 per cent. Conditions to the amount of two units will be allowed.

Entrance examination for admission to the Massachusetts Agricultural College will be held at the following centers: —

In June, ...	Amherst, Department of Physics building. Massachusetts Institute of Technology, Cambridge, Mass. Worcester, Horticultural Hall.
In September, ...	Amherst, Department of Physics building.

Please note that September examinations are held in Amherst only.

Schedule for Entrance Examinations, June 28-30, inclusive, 1917. — The examinations in June will follow this schedule: —

First Day.

7.45 A.M.	Registration.[1]
8.00 A.M.	Plane geometry.
10.00 A.M.	Chemistry.
11.30 A.M.	Botany.
2.00 P.M.	Solid geometry.
4.00 P.M.	Physics.

Second Day.

8.00 A.M.	Required English.
11.00 A.M.	Algebra.
2.00 P.M.	History, required and elective.

Third Day.

8.00 A.M.	French, German, required and elective.
1.00 P.M.	Latin A and B and all one-half credit electives, except those already noted.

Schedule for Entrance Examinations in September. — In September, 1917, the examinations will be given September 12–15, inclusive, and will follow the order indicated below: —

First Day.

1.00 P.M.	Registration.
1.15–5.00 P.M.	Greek A and B.

Second Day.

8.00 A.M.	Plane geometry.
10.00 A.M.	Chemistry.
11.30 A.M.	Botany.
2.00 P.M.	Solid geometry.
4.00 P.M.	Physics.

Third Day.

8.00 A.M.	Required English.
11.00 A.M.	Algebra, agriculture.
2.00 P.M.	History, required and elective.

Fourth Day.

8.00 A.M.	French, German, required and elective.
1.00 P.M.	Latin A and B and all one-half credit electives, except those already noted.

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[1] Candidates who have no examination at the time set for registration may register at the time of their first examination should they so desire.

C. Requirements for Admission.

The requirements for admission are based on the completion of a four-year high school course, or its equivalent, and are stated in terms of units. The term unit means the equivalent of at least four recitations a week for a school year. **Neither more nor less credit will be given in any subject than is indicated in the table below.** Fourteen units must be offered for admission. In the list given below, *every subject in black-faced type is prescribed and no substitution is allowed.* The subjects so typed total eight and one-half units. In addition to these points five and one-half more units must be chosen from the subjects printed in light-faced type. Not more than four half-credit units may be offered. No applicant deficient in both algebra and plane geometry will be admitted.

Agriculture[1] (see also note at end of volume),	½ or 1
Botany,[2]	½ or 1
Chemistry,[2]	1
Algebra,	1½
Plane geometry,	1
Solid geometry,	½
Trigonometry,	½
Physics,[2]	1
Geology,	½
Physiography,	½
Physiology,	½
Zoölogy,[2]	½
History[3] (Ancient; Medieval and Modern; English; General; United States and Civics), *any one,*	1[4]
English 1,	1½
English 2,	1½
Modern Language (elementary French or elementary German),	2
Elementary French,[5]	2
Elementary German,[5]	2
Intermediate French,	1
Advanced French,	1
Intermediate German,	1
Advanced German,	1
Greek A,[1]	2
Greek B,[1]	1
Latin A,	2
Latin B,	1
Commercial geography,[6]	½
Drawing,[6]	½
Manual training,[6]	½ or 1

PRESENTATION OF NOTE-BOOKS. — The keeping of a note-book is required as part of the preparation in those subjects indicated (see note 2, below).

Candidates presenting themselves for examination in such subjects must present at the same time the required note-book, properly certified by the principal. Candidates presenting such subjects on certificates should not present note-books; but their certificates must state that note-books have been satisfactorily completed.

[1] Examination in September only.

[2] Note-book required as part of preparation will be credited as part of the examination.

[3] One must be offered for the required point; one, two or three others may be offered for elective points.

[4] For each offered.

[5] May be offered as elective if not offered to satisfy *prescribed* points.

[6] On certificate only, no examination given.

D. Statement of Preparation Required for Admission.

Agriculture. — Owing to the wide divergence of the methods of teaching agriculture in the public schools, the student will be required to bring a statement from the principal of the amount and kinds of work accomplished and of the text-books used. The examination will be based somewhat upon this information: but it will call for not less than one-half year of creditable work of high school grade. **The examination in agriculture will be given in September only.**

Botany. — For one unit of credit in botany, the work outlined in the statement of requirements issued by the College Entrance Examination Board, or its equivalent, will be accepted. This work should occupy one school year and include laboratory and supplementary text-book study. For one-half unit of credit, work that covers the same ground but occupies half the time required for a full unit of credit will be accepted. These requirements are met by such texts as Steven's "Introduction to Botany" and Bergen and Davis's "Principles of Botany." A note-book containing neat, accurate drawings and descriptive records forms part of the requirement for either the half-unit or the one-unit credit, and this note-book must be presented by all applicants for admission upon examination in this subject. The careful preparation of an herbarium is recommended to all prospective students of this college, although the herbarium is not required.

Chemistry. — The entrance examination in chemistry will cover the work outlined by the College Entrance Examination Board as preparatory for college entrance. In general, this consists of a year of high school chemistry from such text-books as Newell's "Descriptive Chemistry" or Remsen's "Elements of Chemistry," with laboratory work on the general properties of the common elements. The keeping of a note-book is required.

Mathematics. — (*a*) *Required.* — Algebra: The four fundamental operations for rational algebraic expressions; factoring, determination of highest common factor and lowest common multiple by factoring; fractions, including complex fractions; ratio and proportion; linear equations, both numerical and literal, containing one or more unknown quantities; problems depending on linear equations; radicals, including the extraction of the square root of polynomials and numbers; exponents, including the fractional and negative; quadratic equations, both numerical and literal; simple cases of equations with one or more unknown quantities that can be solved by the methods of linear or quadratic equations; problems depending upon quadratic equations; the binomial theorem for positive integral exponents, the formulas for the nth term and the sum of the terms of arithmetic and geometric progressions, with applications.

Plane Geometry: The usual theorems and constructions of good text-books, including the general properties of plane rectilinear figures; the circle and the measurement of angles; similar polygons; areas; regular polygons and the measurement of the circle; the solution of numerous original exercises, including loci problems; applications to the mensuration of lines and plane surfaces.

(*b*) *Elective.* — Solid Geometry: The usual theorems and constructions of good text-books, including the relations of planes and lines in space; the properties and measurement of prisms, pyramids, cylinders and cones; the

sphere and spherical triangle; the solution of numerous original exercises, including loci problems; applications to the mensuration of surfaces and solids.

Plane Trigonometry: A knowledge of the definitions and relations of trigonometric functions and of circular measurements and angles; proofs of the principal formulas and the application of these formulas to the transformation of the trigonometric functions; solution of trigonometric equations, the theory and use of logarithms, and the solution of right and oblique triangles.

Physics. — To satisfy the entrance requirement in physics, the equivalent of at least one unit of work is required. This work must consist of both class-room work and laboratory practice. The work covered in the class-room should be equal to that outlined in Hall & Bergen's "Text-book of Physics" or Millikan & Gale; the laboratory work should represent at least thirty-five experiments involving careful measurements, with accurate recording of each in laboratory note-book. This note-book, certified by the instructor in the subject, must be submitted by each candidate presenting himself for examination in physics; credit for passing the subject will be given on laboratory notes and on the examination paper submitted. Candidates entering on certificate will not be required to present note-books, but the principal's certification must cover laboratory as well as class-room work.

Physiology. — Hough & Sedgwick's "The Human Mechanism;" Martin's "The Human Body; Briefer Course."

Zoölogy, Physiography, Geology. — The following suggestions are made concerning preparation for admission in the subjects named above: —

For physiography, Davis' "Elementary Physical Geography;" Gilbert & Brigham's "Introduction to Physical Geography." For zoölogy, text-books entitled "Animals" or "Animal Studies," by Jordan, Kellogg and Heath; Linville & Kelley's "A Text-book in General Zoölogy." For geology, A. P. Brigham's "A Text-book of Geology" or Tarr's "Elementary Geology."

Applicants for examination in zoölogy are *required* to present certified laboratory note-books; applicants for examination in the other subjects are *advised* to present note-books, if laboratory work has been done. Good note-books may be given credit for entrance. Examination in these subjects will be general, in recognition of the different methods of conducting courses; but students will be examined on the basis of the most thorough secondary school courses.

History. — The required unit must be offered in either ancient history, medieval and modern history, English history, general history, or United States history and civics. Either one, two or three elective units in any of the historical subjects here named may be offered, provided that no unit be offered in the same subject in which the required unit has been offered.

Preparation in history will be satisfactory if made in accordance with the recommendations of the committee of seven of the American Historical Association, as outlined by the College Entrance Examination Board. The examination will require comparisons and the use of judgment by the candidate rather than the mere use of memory, and it will presuppose the use of good text-books, collateral reading and practice in written work. Geographical knowledge may be tested by requiring the location of places and movements on outline maps.

To indicate in a general way the character of the text-book work expected, the texts of the following authors are suggested: Botsford, Morey or Myers,

in ancient history (to 814 A.D.); Adams, West or Myers, in medieval history; Montgomery, Larned or Cheyney, in English history; Myers or Fisher, in general history; Fiske, together with MacLaughlin or Montgomery, in United States history and civics.

English. — For 1916–19 inclusive: —

The study of English in school has two main objects: (1) command of correct and clear English, spoken and written; (2) ability to read with accuracy, intelligence and appreciation.

(1) *Grammar and Composition* (One and One-half Units). — The first object requires instruction in grammar and composition. English grammar should ordinarily be reviewed in the secondary school; and correct spelling and grammatical accuracy should be rigorously exacted in connection with all written work during the four years. The principles of English composition governing punctuation, the use of words, sentences and paragraphs should be thoroughly mastered; and practice in composition, oral as well as written, should extend throughout the secondary school period. Written exercises may well comprise letter-writing, narration, description and easy exposition and argument. It is advisable that subjects for this work be taken from the student's personal experience, general knowledge and studies other than English, as well as from his reading in literature. Finally, special instruction in language and composition should be accompanied by concerted effort of teachers in all branches to cultivate in the student the habit of using good English in his recitations and various exercises, whether oral or written.

(2) *Literature* (One and One-half Units). — The second object is sought by means of two lists of books, headed, respectively, "Reading" and "Study," from which may be framed a progressive course in literature covering four years. In connection with both lists the student should be trained in reading aloud and encouraged to commit to memory some of the more notable passages both in verse and in prose. As an aid to literary appreciation, he is further advised to acquaint himself with the most important facts in the lives of the authors whose works he reads and with their place in literary history.

A. Reading. — The aim of this course is to foster in the student the habit of intelligent reading and to develop a taste for good literature by giving him a first-hand knowledge of some of its best specimens. He should read the books carefully, but his attention should not be so fixed upon details that he fails to appreciate the main purpose and charm of what he reads.

With a view to large freedom of choice, the books provided for reading are arranged in the following groups, from each of which at least two selections are to be made, except as otherwise provided under Group I.: —

Group I. Classics in Translation: The "Old Testament," comprising at least the chief narrative episodes in Genesis, Exodus, Joshua, Judges, Samuel, Kings and Daniel, together with the books of Ruth and Esther; the "Odyssey," with the omission, if desired, of Books I., II., III., IV., V., XV., XVI., XVII.; the "Iliad," with the omission, if desired, of Books XI., XIII., XIV., XV., XVIII., XXI.; the "Æneid." The "Odyssey," "Iliad" and "Æneid" should be read in English translations of recognized literary excellence.

For any one selection from Group I. a selection from any other group may be substituted.

Group II. Shakspere: "Midsummer Night's Dream;" "Merchant of Venice;" "As You Like It;" "Twelfth Night;" "The Tempest;" "Romeo

and Juliet;" "King John;" "Richard II.;" "Richard III.;" "Henry V.;" "Coriolanus;" "Julius Cæsar;"[1] "Macbeth;"[1] "Hamlet."[1]

Group III. Prose Fiction: Malory's "Morte d'Arthur" (about 100 pages); Bunyan's "Pilgrim's Progress," Part I.; Swift's "Gulliver's Travels" (voyages to Lilliput and to Brobdingnag); Defoe's "Robinson Crusoe," Part I.; Goldsmith's "Vicar of Wakefield;" Frances Burney's "Evelina;" Scott's novels, any *one;* Jane Austen's novels, any *one;* Maria Edgeworth's "Castle Rackrent" or "The Absentee;" Dickens' novels, any *one;* Thackeray's novels, any *one;* George Eliot's novels, any *one;* Mrs. Gaskell's "Cranford;" Kingsley's "Westward Ho!" or "Hereward the Wake;" Reade's "The Cloister and the Hearth;" Blackmore's "Lorna Doone;" Hughes's "Tom Brown's School Days;" Stevenson's "Treasure Island" or "Kidnapped" or "Master of Ballantrae;" Cooper's novels, any *one;* Poe's "Selected Tales;" Hawthorne's "The House of the Seven Gables" or "Twice Told Tales" or "Mosses from an Old Manse;" a collection of short stories by various standard writers.

Group IV. Essays, Biography, etc.: Addison and Steele's "The Sir Roger de Coverley Papers" or selections from the "Tatler" and "Spectator" (about 200 pages); selections from Boswell's "Life of Johnson" (about 200 pages); Franklin's "Autobiography;" selections from Irving's "Sketch Book" (about 200 pages) or "Life of Goldsmith;" Southey's "Life of Nelson;" selections from Lamb's "Essays of Elia" (about 100 pages); selections from Lockhart's "Life of Scott" (about 200 pages); Thackeray's "Lectures on Swift, Addison and Steele in the English Humorists;" Macauley: any one of the following essays: "Lord Clive," "Warren Hastings," "Milton," "Addison," "Goldsmith," "Frederic the Great," "Madame d'Arblay:" selections from Trevelyan's "Life of Macaulay" (about 200 pages); Ruskin's "Sesame and Lilies" or "Selections" (about 150 pages); Dana's "Two Years Before the Mast;" Lincoln's "Selections," including at least the two inaugurals, the speeches in Independence Hall and at Gettysburg, the last public address, the letter to Horace Greeley, together with a brief memoir or estimate of Lincoln; Parkman's "The Oregon Trail;" Thoreau's "Walden;" Lowell's "Selected Essays" (about 150 pages); Holmes's "The Autocrat of the Breakfast Table;" Stevenson's "An Inland Voyage" and "Travels with a Donkey;" Huxley's "Autobiography" and selections from "Lay Sermons," including the addresses on "Improving Natural Knowledge," "A Liberal Education" and "A Piece of Chalk;" a collection of "Essays" by Bacon, Lamb, De Quincey, Hazlitt, Emerson and later writers; a collection of "Letters" by various standard writers.

Group V. Poetry: Palgrave's "Golden Treasury" (first series), Books II. and III., with special attention to Dryden, Collins, Gray, Cowper and Burns; Palgrave's "Golden Treasury" (first series), Book IV., with special attention to Wordsworth, Keats and Shelley (if not chosen for study under B); Goldsmith's "The Traveller" and "The Deserted Village;" Pope's "The Rape of the Lock;" a collection of English and Scottish ballads, as, for example, some "Robin Hood" ballads, "The Battle of Otterburn," "King Estmere," "Young Beichan," "Bewick and Grahame," "Sir Patrick Spens" and a selection from later ballads; Coleridge's "The Ancient Mariner," "Christabel" and "Kubla Khan;" Byron's "Childe Harold," Canto III. or IV., and "The Prisoner of Chillon;" Scott's "The Lady of the Lake" or "Marmion;"

[1] If not chosen for study under B.

Macaulay's "The Lays of Ancient Rome," "The Battle of Naseby," "The Armada," "Ivry;" Tennyson's "The Princess" or "Gareth and Lynette," "Lancelot and Elaine" and "The Passing of Arthur;" Browning's "Cavalier Tunes," "The Lost Leader," "How They Brought the Good News from Ghent to Aix," "Home Thoughts from Abroad," "Home Thoughts from the Sea," "Incident of the French Camp," "Herve Riel," "Pheidippides," "My Lost Duchess," "Up at a Villa — Down in the City," "The Italian in England," "The Patriot," "The Pied Piper," "De Gustibus," "Instans Tyrannus;" Arnold's "Sohrab and Rustum"and "The Forsaken Merman;" selections from American poetry, with special attention to Poe, Lowell, Longfellow and Whittier.

B. *Study.* — This part of the requirement is intended as a natural and logical continuation of the student's earlier reading, with greater stress laid upon form and style, the exact meaning of words and phrases, and the understanding of allusions. The books provided for study are arranged in four groups, from each of which one selection is to be made.

Group I. Drama: Shakspere's "Julius Cæsar," "Macbeth," "Hamlet."

Group II. Poetry: Milton's "L'Allegro," "Il Penseroso" and either "Comus" or "Lycidas;" Tennyson's "The Coming of Arthur," "The Holy Grail" and "The Passing of Arthur;" the selections from Wordsworth, Keats and Shelley in Book IV. of Palgrave's "Golden Treasury" (first series).

Group III. Oratory: Burke's "Speech on Conciliation with America;" Macaulay's "Speech on Copyright" and Lincoln's "Speech at Cooper Union;" Washington's "Farewell Address" and Webster's "First Bunker Hill Oration."

Group IV. Essays: Carlyle's "Essay on Burns," with a selection from Burns's "Poems;" Macaulay's "Life of Johnson;" Emerson's "Essay on Manners."

Examination. — However accurate in subject-matter, no paper will be considered satisfactory if seriously defective in punctuation, spelling or other essentials of good usage.

The examination will be divided into two parts, one of which will be on grammar and composition, and the other on literature.

In grammar and composition, the candidate may be asked specific questions upon the practical essentials of these studies, such as the relation of the various parts of a sentence to one another, the construction of individual words in a sentence of reasonable difficulty, and those good usages of modern English which one should know in distinction from current errors. The main test in composition will consist of one or more essays, developing a theme through several paragraphs; the subjects will be drawn from the books read, from the candidate's other studies and from his personal knowledge and experience quite apart from reading.

The examination in literature will include: —

(*a*) General questions designed to test such a knowledge and appreciation of literature as may be gained by fulfilling the requirements defined under "A, Reading," above.

(*b*) A test on the books prescribed for study, which will consist of questions upon their content and structure, and upon the meaning of such words, phrases and allusions as may be necessary to an understanding of the works and an appreciation of their salient qualities of style. General questions may also be asked concerning the lives of the authors, their works and the periods of literary history to which they belong.

French. — Elementary: The necessary preparation for this examination is stated in the description of the two-year course in elementary French recommended by the Modern Language Association, contained in the definition of requirements of the College Entrance Examination Board.

Third and fourth year French (elective subjects for admission). — For a third credit unit in French as an elective subject for entrance, the work heretofore described by the College Entrance Examination Board as "intermediate" is expected. For a fourth credit unit, the work described as "advanced" is expected.

No examination for a third unit in French will be given unless the candidate has presented elementary French on certificate, or has written the examination in elementary French.

No examination for a fourth credit in French will be given unless the candidate has presented both elementary and intermediate French upon certificate, or has written the examination in both elementary and intermediate French.

German. — Elementary: The entrance requirements in German conform to those of the College Entrance Examination Board for elementary German (the standard two-year requirements).

Third and fourth year German (elective subjects for admission). — For a third credit unit in German as an elective subject for entrance, when required units have been offered in German, the work heretofore described by the College Entrance Examination Board as "intermediate" is expected. For a fourth credit unit, the work described as "advanced" is expected.

No examination for a third unit in German will be given unless the candidate has presented elementary German upon certificate, or has written the examination in elementary German.

No examination for a fourth credit in German will be given unless the candidate has presented both elementary and intermediate German upon certificate, or has written the examination for both elementary and intermediate German.

Greek. — Greek will receive credit as an elective requirement upon either examination or certification, as follows. **(The examination in Greek A and Greek B will be given in September only.)**

A. Two credit units will be allowed if satisfactory proficiency is shown (including grammar) in (*a*) the translation of a passage or passages taken from the first four books of Xenophon's "Anabasis," and (*b*) the translation of passages of Attic prose at sight.

B. A third credit unit will be allowed if, in addition to the above, satisfactory proficiency be shown in (*a*) the translation of a passage or passages from the first six books of Homer's "Iliad," and (*b*) translation of passages of Homer's "Iliad" at sight, with questions on the form and constructions of the passages.

Latin. — Latin will receive credit as an elective requirement upon either examination or certification, as follows: —

A. Two credit units will be allowed if satisfactory proficiency is shown (including grammar) in (*a*) the translation of a passage or passages taken from Cæsar's "Gallic War," covering at least four books, and (*b*) the translation of passages of Latin prose at sight.

B. A third credit unit will be allowed if, in addition to the above, satisfactory proficiency be shown in (*a*) the translation of a passage or passages

selected from either Books I. to VI. of Virgil's "Æneid," or six orations of Cicero, including those against Catiline; and (*b*) the translation into Latin prose of a passage of connected English narrative based on some portion of Cæsar's "Gallic War," Books I. to IV.

COMMERCIAL GEOGRAPHY.[1] — Preparation should be made in a course equivalent to that laid down in Adams' "Commercial Geography," Trotter's "Geography of Commerce," or a similar work. (No examination given.)

DRAWING.[1] — The applicant may offer either freehand or mechanical drawing or both. He must be able to make an accurate freehand sketch, in either outline or light and shade, of the appearance of a group of geometric solids, and have a sufficient knowledge of perspective to enable him to draw correctly a simple geometric model from memory; or, if he present mechanical drawing, he must have working familiarity with drawing instruments, and be able to make an accurate inked working drawing, in orthographic projection, of some simple object. Emphasis is laid on facility in doing good freehand lettering. For a limitation of the work that may be presented, see "Manual Training." (No examination given.)

MANUAL TRAINING.[1] — An entrance credit of one-half or one unit is allowed for manual training, on the presentation of a certificate from the principal of the school showing the scope and character of the applicant's work. The preparation may include mechanical drawing, working in wood, metals, leather, etc. When mechanical drawing is presented as a part of the work in manual training, no other credit for drawing will be allowed. No examination is given in this subject; applicants must present certificates to secure credit.

E. ADMISSION TO ADVANCED STANDING.

Candidates for admission to advanced standing, in addition to meeting the regular entrance requirements, must also pass examinations in those subjects already pursued by the class they desire to enter. To meet this requirement, a student transferring to this college from another college or university of recognized standing must present the following credentials: —

1. A letter of honorable dismissal from the institution with which he has been connected.
2. A statement or certificate of his entrance record.
3. A statement from the proper officer showing a complete record of his work while in attendance.
4. A marked catalogue showing the courses pursued.

These credentials should be presented to the registrar. Applications will be judged wholly on their merits and the college may prescribe additional tests before accepting applicants or determining the standing to be granted them.

F. OTHER INFORMATION ABOUT ENTRANCE.

1. The privileges of the college may be withdrawn from any student at any time if such action is deemed advisable. (It is immaterial whether the pupil has entered by certificate or by examination.)
2. The examination in each subject may be either oral or written, or both. The standard required for passing an entrance examination is 65 per cent.

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[1] On certificate only; no examination given.

3. Candidates must receive credit for twelve units out of the total number required for entrance, and will be conditioned in those subjects not passed. Not more than five and one-half credits from the elective group will be accepted. No candidate deficient in both algebra and plane geometry will be admitted.

4. Examinations for the removal of entrance conditions will be held as follows: (1) First entrance condition examination during the first week of the second term. (2) Second entrance condition examination before the beginning of the period of final examinations of the second term, upon the payment of a fee of $5 to the treasurer.

5. Credits for entrance requirements, whether gained by certificate or by examination, will hold good for one year.

6. Examinations in part of the subjects required for entrance may be taken one year before entering college.

7. For information concerning expenses, scholarships, etc., see "General Information."

8. For information concerning admission to short courses see "Short Courses."

G. Unclassified Students.

All requests for information concerning admission of unclassified students should be addressed to Dean Edward M. Lewis, chairman of committee on unclassified students.

Students not candidates for a degree (unclassified students) are admitted under the following provisions: —

1. No entrance examination is required, but applicants must bring certificates showing that they have finished a four-year high school course or its equivalent, and furnish satisfactory testimonials as to moral character.

2. No applicant under twenty-one years of age will be admitted as an unclassified student.

3. Each unclassified student must take from the regular courses a minimum of twelve credit hours a week.

4. In order to be admitted to any course, an unclassified student must have had all prerequisite subjects for that course.

5. Every unclassified student must do all the work of the courses elected, and take all examinations therein. In order to pass such courses he must attain a grade of at least 75 per cent. An unclassified student who passes in less than two-thirds of his work will be dropped from college.

6. All unclassified students are subject to the supervision of a special committee.

7. Any unclassified student may be dropped from college at any time if his presence in any class is undesirable or his work is unsatisfactory; and no unclassified student will be allowed to remain in college more than four semesters without the special permission of the faculty.

8. Unclassified students are subject to the regulations applying to classified students.

9. No student of this or any other institution who has not done efficient work therein shall be permitted to register as an unclassified student.

10. No unclassified student shall be allowed to participate in any intercollegiate contests.

H. One-year Vocational Course in Poultry Husbandry.

Purpose. — This course is designed for graduates of the agricultural vocational schools and others who wish to prepare themselves for practical poultry keeping and can spend only one year at college.

Scope. — The work covers seven detailed courses in poultry husbandry, as well as short-course work in fruit growing, market gardening, bee culture, animal husbandry or other subjects that will be helpful to poultry raisers. In addition to classroom and laboratory exercises each student is required to put in from 25 to 30 hours per week at the plant in the care and management of poultry for the purpose of becoming proficient in the various branches of the work.

Entrance Requirements. — Applicants must be at least eighteen years of age and have a good elementary education.

Fees. — There is no tuition for residents of Massachusetts, but a laboratory fee of $5 is required for both the fall and spring terms.

Note. — The course is limited to 16 students.

Courses of Instruction.

TABLE OF FRESHMAN AND SOPHOMORE SUBJECTS.

[The figures indicate the number of credit hours a week. For details, see the descriptions of courses.]

Freshman Year.

First Term.

All work required.

Subject.	Courses and Numbers.	Credit Hours per Week.
Chemistry,	Chemistry 1 or 4,	3
Algebra,	Mathematics 1,	5
Language,	French or German 1 or 4,	3
English,	English 1,	3
Agriculture and horticulture,	Agronomy 1, Animal Husbandry 1, Pomology 1, Poultry 1.	2
Tactics,	Military 1,	1
Drill,	Military 4,	1
Hygiene,	Physical Education 1,	1
Public speaking,	Public Speaking 1 (one-third of the class),	1
		20

College life (attendance without credit).

Second Term.

Chemistry,	Chemistry 2 or 5,	3
Algebra,	Mathematics 2,	2
Trigonometry,	Mathematics 5,	3
Language,	French or German 2 or 5,	3
English,	English 2,	3
Agriculture and horticulture,	Agronomy 1, Animal Husbandry 1, Pomology 1, Poultry 1.	2
Gymnastics,	Physical Education 5,	1
Geology,	Geology 2,	2
Public speaking,	Public Speaking 1 (one-third of class),	1
		20

College life (attendance without credit).

Freshman Year — *Concluded.*

Third Term.

Subject.	Courses and Numbers.	Credit Hours per Week.
Chemistry,	Chemistry 3 or 6,	3
Solid geometry,	Mathematics 3,	3
Mensuration,	Mathematics 6,	2
Language,	French or German 3 or 6,	3
English,	English 3,	3
Botany,	Botany 3,	3
Tactics,	Military 3,	1
Drill,	Military 6,	1
Public speaking,	Publi3 Speaking 1 (one-third of class),	1
		20

College life (attendance without credit).

Sophomore Year.

First Term.

Subject.	Course Number.	Class Hours.	Two Hour Laboratory Periods.	Credit Hours per Week.
Required.				
Physics,	25	3	1	4
Zoölogy,	25	1	2	3
Botany,	25	1	2	3
English,	25	2	–	2
Military,	25	1	–	1
Military,	28	–	1	1
Total required,	–	–	–	14
Elective.				
Chemistry,	25	1	2	3
French,	25 or 28	3	–	3
German,	25 or 28	3	–	3
Drawing,	25	–	3	3
Animal husbandry,	25	2	1	3
Rural engineering,	25	–	2	2

SOPHOMORE YEAR — *Concluded.*

SECOND TERM.

SUBJECT.	Course Number.	Class Hours.	Two Hour Laboratory Periods.	Credit Hours per Week.
Required.				
Physics,	26	2	1	3
Agricultural economics,	26	5	-	5
English,	26	2	-	2
Physical education,	26	-	1	1
	-	-	-	11
Elective.				
Chemistry,	26	1	2	3
French,	26 or 29	3	-	3
German,	26 or 29	3	-	3
Mathematics,	26	2	-	2
Drawing,	26	-	3	3
Entomology,	26	3	-	3
Animal husbandry,	26	1	2	3
Rural engineering,	26	-	2	2
Botany,	26	1	2	3
Economic sociology,	26	5	-	5

THIRD TERM.

SUBJECT.	Course Number.	Class Hours.	Two Hour Laboratory Periods.	Credit Hours per Week.
Required.				
Rural sociology,	27	3	-	3
Agronomy,	27	4	1	5
English,	27	2	-	2
Military,	27	1	-	1
Military,	30	-	1	1
Total required,	-	-	-	12
Elective.				
Chemistry,	27	1	4	5
Chemistry,	30	3	2	5
French,	27 or 30	3	-	3
German,	27 or 30	3	-	3
Mathematics,	27	-	3	3
Drawing,	27	-	3	3
Entomology,	27	-	2	2
Geology,	27	3	2	5
Physics,	27	4	1	5
Horticulture,	27	2	1	3
Zoölogy,	27	1	2	3

MAJORS: JUNIOR AND SENIOR YEARS.

General Statement.

A major consists of 45 credit hours of correlated work, to be arranged by the student and an instructor called the adviser.

The list of courses found under each major on subsequent pages should not be considered as necessarily a rigid program to be followed. The heads of departments have suggested this series of courses as the best for the average man majoring in their departments. Advisers may, however, make modifications to suit the particular needs of the student, provided these modifications conform precisely to the class schedule as published for the year.

Rules governing Majors.

Rule 1. *Election.* — Each student, before the first term of his junior year, shall elect a major subject from the list of majors given below; and this major shall consist of 45 credit hours of correlated work.

Rule 2. *Minimum Credits.* — The minimum number of credits for graduation shall be 234 credit hours, inclusive of military drill and physical education.

Rule 3. *Maximum Credits.* — The maximum number of credits for any term of the junior or senior year shall be 22; the minimum shall be 19.

Rule 4. *Humanities and Rural Social Science.* — A minimum of 18 credit hours in the Divisions of the Humanities and Rural Social Science will be required of all students during their junior and senior years, with the following restriction: that a minimum of 5 credit hours will be required in each of the divisions, except that the minimum for the class of 1918 shall be 22 hours.

Rule 5. *Advisers.* — The work of each junior and senior will be under the immediate supervision of an instructor designated as major adviser. Ordinarily, the major adviser will be the head of the department in which the student intends to elect his major. Each student should consult with the adviser as soon as possible. The adviser has full authority to prescribe the student's work up to 45 hours. It is understood, however, that so far as practicable the individual needs of the student will be recognized. It is also hoped and expected that students will be disposed to seek the counsel of the adviser with respect to the remaining courses required for graduation.

Rule 6. *Free Electives.* — Each student during his junior and senior years is required to take 45 hours in his major and also 18 hours in the Divisions of the Humanities and Rural Social Science, making a total of 63 hours (but see Rule 4). He is allowed free choice of courses to complete his required hours.

Rule 7. *Registration.* — No junior or senior shall register until his major course of study is approved by his adviser.

(1) Course cards for recording the election of majors will be issued from the registrar's office three weeks before the close of each term.

(2) This card must be submitted by each student to his major adviser, who will lay out the course for the succeeding term and countersign the card.

(3) Each course card must be filled out, giving the name of student, his college address, the name of parent or guardian, and the student's home address. When the major courses have been entered on this card, and the hours

of free elections added by the student, the card must be returned to the registrar one week before the beginning of the final examination period.

RULE 8. *Changes.* — Applications for changes may be made to the dean in writing at any time; when approved by him and by the committee on scholarship, they become operative at the beginning of the term following, provided that no change in the selection of a major may be made by any student after registration day of his senior year.

Agriculture. (Major.)

Professor James A. Foord, *Adviser.*

[The heavy-faced type indicates the term in which the course is given.]

Course.	Number.	Credit.	Term.	Sophomore.	Credit.	Junior.	Credit.	Senior.	Credit.
Agronomy,	50 **I.**	5	**I.**	Animal Husbandry 25,	3	Agronomy 50,	5	Animal Husbandry 75,	3
Agronomy,	76 **III.**	5		Rural Engineering 25,	2	Dairying 50,	5	Rural Engineering 75,	5
Animal Husbandry,	51 **III.**	3							
Animal Husbandry,	75 **I.**	3	**II.**	Mathematics 26,	2			Farm Management 75,	3
Animal Husbandry,	76 **II.**	3		Animal Husbandry 26,	3			Animal Husbandry 76,	3
Dairying,	50 **I.**	5		Rural Engineering 26,	2				
Farm Management,	75 **II.**	3	**III.**	Chemistry 30,	5	Microbiology 50,	5	Agronomy 76,	5
Farm Management,	76 **III.**	5		Mathematics 27,	3	Animal Husbandry 51,	3	Farm Management 76,	5
Microbiology,	50 **I.**			Horticulture 27,	3				
or		5							
Microbiology,	50 **III.**		**IV.**						
Rural Engineering,	75 **I.**	5							
		42							

Sophomore Elective Prerequisites (Required). — Animal Husbandry 25 and 26, Rural Engineering (shop work) 25 and 26, Chemistry 30, Mathematics 26 and 27, and Horticulture 27.

Additional Information. — Dairying 75, Pomology 50 and 51, Rural Engineering 78, and Veterinary 51 and 78 are suggested as additional courses for the student fitting himself for general agriculture.

AGRONOMY. (Major.)

Assistant Professor EARL JONES, *Acting Adviser.*

[The heavy-faced type indicates the term in which the course is given.]

COURSE.	Number.	Credit.	Term.	Sophomore.	Credit.	Junior.	Credit.	Senior.	Credit.
Agronomy,	50 **I.**	5	**I.**	Chemistry 25,	3	Agronomy 50,	5	Agronomy 75,	5
Agronomy,	51 **III.**	5		German 25 or 28,	3	Chemistry 51,	8	Animal Husbandry 75,	5
Agronomy,	75 **I.**	5							
Agronomy,	77 **II.**	5	**II.**	Botany 26,	3	Chemistry 52,	8	Agronomy 77,	5
Animal Husbandry,	75 **I.**	3		Chemistry 26,	3				
Chemistry,	51 **I.**	8		German 26 or 29,	3				
				Mathematics 26,	2				
Chemistry,	52 **II.**	8	**III.**	German 27 or 30,	3	Agronomy 51,	5	Farm Management 76,	5
Farm Management,	76 **III.**	5		Mathematics 27,	3				
				Geology 27,	5				
		44							
			IV.						

SOPHOMORE ELECTIVE PREREQUISITES (REQUIRED). — Chemistry 25 and 26, German 25 or 28, 26 or 29, 27 or 30, Geology 27, Botany 26.
ADVISED. — Mathematics 26 and 27.

Animal Husbandry. (Major.)

Professor John C. McNutt, *Adviser.*

[The heavy-faced type indicates the term in which the course is given.]

Course.	Number.	Credit.	Term.	Sophomore.	Credit.	Junior.	Credit.	Senior.	Credit.
Agronomy,	50 **I.**	5	**I.**	Animal Husbandry 25,	3	Agronomy 50,	5	Animal Husbandry 75,	3
Animal Husbandry,	51 **III.**	3				Veterinary 50,	5		
Animal Husbandry,	50 **II.**	1				Dairying 50,	5		
Animal Husbandry,	52 **III.**	3	**II.**	Animal Husbandry 26,	3	Animal Husbandry 50,	1	Animal Husbandry 76,	3
Animal Husbandry,	75 **I.**	3						Animal Husbandry 78,	3
Animal Husbandry,	76 **II.**	3						Farm Management 75,	3
Animal Husbandry,	77 **III.**	3	**III.**	Chemistry 30,	5	Animal Husbandry 51,	3	Animal Husbandry 80,	1
Animal Husbandry,	78 **II.**	3				Animal Husbandry 52,	3	Animal Husbandry 77,	3
Animal Husbandry,	80 **III.**	1						Farm Management 76,	5
Dairying,	50 **I.**	5	**IV.**						
Farm Management,	75 **II.**	3							
Farm Management,	76 **III.**	5							
Veterinary,	50 **I.**	5							
		43							

Sophomore Elective Prerequisites (Required). — Animal Husbandry 25 and 26, Chemistry 30.

Additional Information. — The balance of the sophomore electives allowed are left to the student to choose.

Dairying. (Major.)

Professor William P. B. Lockwood, *Adviser.*

[The heavy-faced type indicates the term in which the course is given.]

Course.	Number.	Credit.	Term.	Sophomore.	Credit.	Junior.	Credit.	Senior.	Credit.
Animal Husbandry,	52 **III.**	3	**I.**	Animal Husbandry 25,	3	Dairying 50,	5	Animal Husbandry 75,	3
Animal Husbandry,	75 **I.**	3		Rural Engineering 25,	2	Microbiology 50,	5	Microbiology 82,	5
Animal Husbandry,	76 **II.**	3							
Dairying,	50 **I.**	5	**II.**	Animal Husbandry 26,	3	Rural Engineering 77,	5	Farm Management 75,	3
Dairying,	51 **III.**	5		Rural Engineering 26,	2	Microblology 51,	5	Animal Husbandry 76,	3
Dairying,	75 **II.**	5				(Prerequisite to 82.)		Dairying 75,	5
Dairying,	76 **III.**	5	**III.**	Chemistry 30,	5	Animal Husbandry 52,	3	Dairying 76,	5
Farm Management,	75 **II.**	3				Dairying 51,	5		
Microbiology,	50 **I.**	5							
Microbiology,	82 **I.**	5							
Rural Engineering,	77 **II.**	5	**IV.**						
		47							

Sophomore Elective Prerequisites (Required). — Animal Husbandry 25 and 26, Rural Engineering 25 and 26, Chemistry 30.
Additional Information. — The balance of the sophomore electives allowed are left to the student to choose.

Poultry Husbandry. (Major.)

Professor John C. Graham, *Adviser.*

[The heavy-faced type indicates the term in which the course is given.]

Course.	Number.	Credit.	Term.	Sophomore.	Credit.	Junior.	Credit.	Senior.	Credit.
Agricultural Economics,	75 **I.**	5	**I.**			Poultry 50,	3	Poultry 76,	5
Animal Husbandry,	51 **III.**	3				Poultry 51,	2	Poultry 77,	5
Poultry Husbandry,	50 **I.**	3				Agricultural Economics 75,	5	Pomology 50,	3
Poultry Husbandry,	51 **I.**	2	**II.**			Poultry 52,	3	Poultry 75,	5
Poultry Husbandry,	52 **II.**	3						Veterinary 86,	3
Poultry Husbandry,	53 **III.**	5							
Poultry Husbandry,	54 **III.**	2	**III.**			Poultry 53,	5		
Poultry Husbandry,	75 **II.**	5				Poultry 54,	2		
Poultry Husbandry,	76 **I.**	5				Animal Husbandry 51,	5		
Poultry Husbandry,	77 **I.**	5	**IV.**						
Pomology,	50 **I.**	3							
Veterinary Science,	86 **II.**	3							
		44							

Sophomore Recommendations. — Students intending to major in Poultry Husbandry are urged to take Zoölogy 27.

Advised. — Juniors who did not take Zoölogy 27 as sophomores are strongly advised to include it in their program.

Floriculture.

Associate Professor Arno H. Nehrling, *Adviser*.

[The heavy-faced type indicates the term in which the course is given.]

Course.	Number.	Credit.	Term.	Sophomore.	Credit.	Junior.	Credit.	Senior.	Credit.
Botany,	50 **I.**	2	**I.**	Drawing 25,	3	Floriculture 50,	4	Floriculture 75,	3
Botany,	51 **II.**	2				Floriculture 53,	3	Horticulture 50,	5
Entomology,	26 **II.**	3				Botany 50,	2		
Floriculture,	50 **I.**	4	**II.**	Drawing 26,	3	Floriculture 51,	4	Floriculture 77,	3
Floriculture,	51 **II.**	4		Entomology 26,	3	Floriculture 54,	3	Floriculture 76,	3
Floriculture,	52 **III.**	4		Botany 26,	3	Entomology 26,	5		
						Botany 51,	2		
Floriculture,	53 **I.**	3	**III.**	Drawing 27,	3	Floriculture 52,	4	Floriculture 80,	3
Floriculture,	54 **II.**	3		Entomology 27,	2	Floriculture 78,	3	Horticulture 51,	5
Floriculture,	75 **I.**	3		Horticulture 27,	3				
Floriculture,	76 **II.**	3							
Floriculture,	77 **II.**	3	**IV.**						
Floriculture,	78 **III.**	3							
Floriculture,	80 **III.**	3							
Horticulture,	50 **I.**	5							
Horticulture,	51 **III.**	5							
		50							

Sophomore Elective Prerequisites. — Drawing 25, 26 and 27, Entomology 26 and 27, Botany 26 and Horticulture 27.

Additional Information. — The rest of the sophomore electives allowed are left to the student to choose. Horticulture 50 and 51 will be taken by seniors.

Advised. — The department advises all students who major in this subject to take Botany 78 and Landscape Gardening 75.

FORESTRY. (Major.)

Professor WILLIAM D. CLARK, *Adviser.*

[The heavy-faced type indicates the term in which the course is given.]

Course.	Number.	Credit.	Term.	Sophomore.	Credit.	Junior.	Credit.	Senior.	Credit.
Botany,	50 **I.**	2	**I.**	Drawing 25,	3	Forestry 50,	3	Forestry 75,	5
Botany,	50 **II.**	2		Rural Engineering 25,	2	Landscape Gardening 50,	5		
Entomology,	75 **III.**	4				Horticulture 50,	5		
						Botany 50,	2		
Forestry,	50 **I.**	3	**II.**	Drawing 26,	3	Forestry 51,	3		
Forestry,	51 **II.**	3		Mathematics 26,	2	Botany 51,	2		
Forestry,	53 **III.**	3		Entomology 26,	3	Landscape Gardening 51,	4		
Forestry,	54 **IV.**	5		Botany 26,	3				
Forestry,	75 **I.**	5	**III.**	Drawing 27,	3	Forestry 53,	3	Forestry 78,	3
Forestry,	78 **III.**	3		Mathematics 27,	2	Horticulture 51,	5		
Horticulture,	50 **I.**	5		Entomology 27,	3	Entomology 75,	4		
				Horticulture 27,	3				
Horticulture,	51 **III.**	5	**IV.**			Landscape Gardening 53,	5		
Landscape Gardening,	50 **I.**	5				Forestry 54,	5		
Landscape Gardening,	51 **II.**	4							
		49							

SOPHOMORE ELECTIVE PREREQUISITES (REQUIRED). — Drawing 25, 26 and 27, Rural Engineering 25, Mathematics 26 and 27, Entomology 26 and 27, Botany 26, Horticulture 27.

ADDITIONAL INFORMATION. — Substitutions according to individual needs may be made in conference with the adviser.

Landscape Gardening. (Major.)

Professor Frank A. Waugh, *Adviser*.

[The heavy-faced type indicates the term in which the course is given.]

Course.	Number.	Credit.	Term.	Sophomore.	Credit.	Junior.	Credit.	Senior.	Credit.
Horticulture,	50 **I.**	5	**I.**	Drawing 25,	3	Landscape Gardening 50,	5	Landscape Gardening 75,	3
Horticulture,	51 **III.**	5				Horticulture 50,	5		
Landscape Gardening,	50 **I.**	5				Drawing 25,	3		
Landscape Gardening,	51 **II.**	4	**II.**	Drawing 26,	3	Landscape Gardening 51,	4	Landscape Gardening 76,	
Landscape Gardening,	52 **III.**	5		Mathematics 26,	2	Drawing 26,	3		
Landscape Gardening,	53 **IV.**	5		Entomology 26,	3				
Landscape Gardening,	75 **I.**	3	**III.**	Drawing 27,	3	Landscape Gardening 52,	5	Landscape Gardening 78 or 79,	3
Landscape Gardening,	76 **II.**	4		Mathematics 27,	3	Horticulture 51,	5	Landscape Gardening 77,	4
Landscape Gardening,	77 **III.**	4		Horticulture 27,	3	Drawing 27,	3		
						Landscape Gardening 78 or 79,	3		
Landscape Gardening,	78 **III.**	3	**IV.**			Landscape Gardening 53,	5		
or									
Landscape Gardening,	79 **III.**	3							
		46							

Sophomore Elective Prerequisites (Required). — Drawing 25, 26 and 27, Mathematics 26 and 27, Horticulture 27.

Additional Information. — Modifications may be permitted when they appear advisable.

Pomology. (Major.)

Professor Fred C. Sears, *Adviser*.

[The heavy-faced type indicates the term in which the course is given.]

Course.	Number.	Credit.	Term.	Sophomore.	Credit.	Junior.	Credit.	Senior.	Credit.
Agronomy,	77 **II.**	5	**I.**	Rural Engineering 25,	2	Pomology 50,	3	Pomology 75,	3
Rural Engineering,	76 **I.**	5				Rural Engineering 76,	5	Pomology 77,	5
								Agronomy 75,	5
Entomology,	26 **II.**	3	**II.**	Botany 26,	3	Pomology 51,	3	Pomology 76,	3
Entomology,	27 **III.**	2		Rural Engineering 26,	2	Entomology 26,	5	Agronomy 77,	5
Pomology,	50 **I.**	3		Entomology 26,	3				
Pomology,	51 **II.**	3	**III.**	Horticulture 27,	3	Pomology 52,	3	Pomology 78,	3
Pomology,	52 **III.**	3		Entomology 27,	2	Entomology 27,	3		
Pomology,	75 **I.**	3							
Pomology,	76 **II.**	3	**IV.**			Pomology 53,	5		
Pomology,	77 **I.**	5							
Pomology,	78 **III.**	3							
		38							

Sophomore Elective Prerequisites (Required). — Horticulture 27, Entomology 26 and 27.

Advised. — Rural Engineering 25 and 26, Botany 50.

Additional Information. — The rest of the sophomore electives allowed are left to the student to choose.

Economic Botany. (Major.)

Professor A. Vincent Osmun, *Adviser.*

[The heavy-faced type indicates the term in which the course is given.]

Course.	Number.	Credit.
Botany,	52 **I.**	3
Botany,	53 **II.**	3
Botany,	54 **III.**	3
Botany,	55 **I.**	3
Botany,	56 **II.**	3
Botany,	75 **I.**	5
Botany,	76 **II.**	5
Botany,	77 **III.**	5
Botany,	78 **I.**	5
Botany,	79 **II.**	5
Botany,	80 **III.**	5
Botany,	82 **II.**	3
Botany,	83 **III.**	3
Botany,	86 **I.**	1
Botany,	87 **II.**	1
Botany,	88 **III.**	1
Chemistry,	51 **I.**	8
		62

Term.	Sophomore.	Credit.	Junior.	Credit.	Senior.	Credit.
I.	Chemistry 25,	3	Botany 52,	3	Botany 75,	5
	German 25 or 28,	3	Botany 55,	3	Botany 78,	5
			Chemistry 51,	8	Botany 86,	1
II.	Chemistry 26,	3	Botany 53,	3	Botany 76,	5
	German 26 or 29,	3	Botany 56,	3	Botany 79,	5
	Botany 26,	3			Botany 82,	3
					Botany 87,	1
III.	German 27 or 30,	3	Botany 54,	3	Botany 77,	5
					Botany 80,	5
					Botany 83,	3
					Botany 88,	1
IV.						

Sophomore Elective Prerequisites (Required). —German 25 or 28, 26 or 29, 27 or 30, Botany 26.

Advised. — Chemistry 25 and 26.

Additional Information. — The balance of the sophomore electives allowed are left to the student to choose. Selection of 45 credits of the above (Pathology 75, 76 and 77, Physiology 78, 79 and 80).

Agricultural Chemistry. (Major.)

Professor Charles A. Peters, *Adviser*.

[The heavy-faced type indicates the term in which the course is given.]

Course.	Number.	Credit.
Chemistry,	51 **I.**	8
Chemistry,	52 **II.**	8
Chemistry,	60 **I.**	3
Chemistry,	61 **II.**	3[1]
Chemistry,	62 **III.**	5
Chemistry,	65 **III.**	5
Chemistry,	76 **I.**	5
Chemistry,	77 **II.**	3
Chemistry,	80 **I.**	5
Chemistry,	87 **III.**	3
Chemistry,	90 **II.**	3[2]
Chemistry,	92 **II.**	
Chemistry,	94 **II.**	
Chemistry,	91 **III.**	5
Chemistry,	93 **II.**	
Chemistry,	95 **III.**	
		54[3]

Term.	Sophomore.	Credit.	Junior.	Credit.	Senior.	Credit.
I.	Chemistry 25,	3	Chemistry 51,	8	Chemistry 76,	5
	German 25 or 28,	3	Chemistry 60,	3	Chemistry 80,	5
II.	Chemistry 26,	3	Chemistry 52,	8	Chemistry 77,	3
	German 26 or 29,	3	Chemistry 61,	3[1]	Chemistry 90, 92, 94,	3[2]
	Entomology 26,	3				
III.	Chemistry 27,	5	Chemistry 62,	5	Chemistry 91, 93, 95,	5
	German 27 or 30,	3	Chemistry 65,	5	Chemistry 87,	3
	Entomology 27,	2				
IV.						

Sophomore Elective Prerequisites (Required). — Chemistry 25, 26 and 27.

Advised. — German 25 or 28, 26 or 29, 27 or 30, Entomology 26 and 27.

Additional Information. — The balance of the sophomore electives allowed are left for the student to choose.

[1] Course 61 is given as a 5-credit course in 1916-17.

[2] Courses 90, 92, 94 may be changed from 3 credits to an option of 3 or 5 credits in 1917-18.

[3] To get the allowed 45 credits the student will select one of the following groups of courses: 90 and 91, or 92 and 93, or 94 and 95, together with the balance from courses shown above.

Economic Entomology. (Major.)

Professor Henry T. Fernald, *Adviser*.

[The heavy-faced type indicates the term in which the course is given.]

Course.	Number.	Credit.	Term.	Sophomore.	Credit.	Junior.	Credit.	Senior.	Credit.
Botany,	50 **I.**	2	**I.**	French 25-28, or German 25-28,	3	Botany 50,	2	Entomology 76,	5
Botany,	51 **II.**	2		Chemistry 25,	3	Zoölogy 50,	3		
Entomology,	50 **I.**	3				Entomology 50,	3		
Entomology,	51 **II.**	3							
Entomology,	52 **III.**	3							
Entomology,	75 **III.**	4	**II.**	French 26-29, or German 26-29,	3	Zoölogy 51,	3	Entomology 77,	3
Entomology,	76 **I.**	5		Entomology 26,	3	Entomology 51,	3	Zoölogy 76,	3
Entomology,	77 **II.**	3		Botany 26,	3	Botany 51,	2	Entomology 90,	3
						Chemistry 61,	3		
Entomology,	78 **III.**	4	**III.**	French 27-30, or German 27-30,	3	Zoölogy 52,	3	Entomology 78,	4
Entomology,	90 **II.**	3		Entomology 27,	2	Entomology 52,	3	Entomology 75,	4
Zoölogy,	50 **I.**	3		Chemistry 27,	5				
Zoölogy,	51 **II.**	3	**IV.**						
Zoölogy,	52 **III.**	3							
Zoölogy,	54 **II.**	3							
		38							

Sophomore Elective Prerequisites (Required). — Entomology 26 and 27, Botany 26.

Advised. — French or German 25 or 28, 26 or 29, 27 or 30, Chemistry 25, 27 and 61.

Additional Information. — The balance of the sophomore electives allowed are left for the student to choose. Juniors are advised to take Entomology 60. In 1916-17 Entomology 26 and 27 will be taken by juniors as part of their major. Beginning 1917-18 the regular junior courses 50, 51 and 52 will be in operation.

Microbiology. (Major.)

Professor Charles E. Marshall, *Adviser.*

[The heavy-faced type indicates the term in which the course is given.]

Course.	Number.	Credit.
Chemistry,	51 **I.**	8
Chemistry,	52 **II.**	8
Microbiology,	50 **I.**	
or		5
Microbiology,	50 **III.**	
Microbiology,	51 **I.**	
or		
Microbiology,	51 **II.**	5
or		
Microbiology,	51 **III.**	
Microbiology,	52 **III.**	5
Microbiology,	81 **I.**	
or		
Microbiology,	82 **I.**	5
or		
Microbiology,	83 **I.**	
Microbiology,	80 **II.**	
or		
Microbiology,	75 **II.**	5
or		
Dairying,	75 **I.**	
		41

Term.	Sophomore.	Credit.	Junior.	Credit.	Senior.	Credit.
I.	Chemistry 25,	3	Microbiology 50,	5	Microbiology 81,	5
	German or French 25 or 28,	3	Microbiology 51,	5	Microbiology 82,	5
			Chemistry 51,	8	Microbiology 83,	5
II.	German or French 26 or 29,	3	Microbiology 51,	5	Microbiology 75,	5
			Chemistry 52,	8	Microbiology 80,	5
					Dairying 75,	5
III.	Chemistry 27,	5	Microbiology 50,	5	Microbiology 76,	5
	German or French 27 or 30,	3	Microbiology 51,	5		
	Physics 27,	5	Microbiology 52,	5		
IV.						

Sophomore Elective (Recommendations). — German or French 25 or 28, 26 or 29, 27 or 30, Chemistry 25 and 27, and Physics 27.

Additional Information. — The rest of the sophomore electives allowed are left for the student to choose. Microbiology 51, fall term, will be taken by students who have had Microbiology 50 the preceding spring, and by those who are permitted to omit Microbiology 50.

Rural Journalism. (Major.)

Associate Professor Robert W. Neal, *Adviser*.

[The heavy-faced type indicates the term in which the course is given.]

Course.	Number.	Credit.	Term.	Sophomore.	Credit.	Junior.	Credit.	Senior.	Credit.
Rural Journalism, ...	50 **I.**	3	**I.**			Journalism 50, . . .	3	Journalism 77, . . .	3
Rural Journalism, ...	51 **II.**	3				[Journalism 53, . . .	3]	Journalism 80, . . .	4(5)
						Agricultural Economics 51,	5		
Two out of three: —			**II.**	Economics and Sociology 26,	5	Journalism 51, . . .	3	Journalism 77, . . .	3
[Rural Journalism, ...	53 **I.**	3]				Journalism 54, . . .	3	Journalism 81, . . .	4(5)
Rural Journalism, ...	54 **II.**	3				Economics and Sociology 51,	5		
Rural Journalism, ...	55 **III.**	3							
Two out of three: —			**III.**			Journalism 55, . . .	3	[Journalism 77, . . .	3]
Rural Journalism, ...	77 **I.**	3						Journalism 82, . . .	4(5)
Rural Journalism, ...	78 **II.**	3							
Rural Journalism, ...	79 **III.**	3							
All: —									
Rural Journalism, ...	80 **I.**	4(5)							
Rural Journalism, ...	81 **II.**	4(5)							
Rural Journalism, ...	82 **III.**	4(5)							
Agricultural Economics, ...	51 **I.**	5	**IV.**						
Economics and Sociology, ...	51 **II.**	5							
Courses to be individually prescribed for remainder of 45 hours.		5							
		45							

Sophomore Prerequisites. — All sophomore English; Economics and Sociology 26. **II.**

Sophomore Recommendations. — French or German 25 (28), 26 (29), 27 (30); Drawing 25. *For agricultural journalism especially:* Animal Husbandry 25, 26, Chemistry 30, Entomology 26, 27.

Advised. — French or German at least two years in college; at least two courses in literature; Music; Landscape 75, 78; Chemistry 87; Entomology 90; Microbiology 50; (Veterinary 78); Zoölogy 27; Geology 27; Agricultural Education 50, 53; Rural Sociology 50, 72; other courses in Economics and Sociology, Rural Sociology, Agricultural Economics, History and Government. *Especially for agricultural journalism:* Agronomy 50, 51; Animal Husbandry 51; Dairying 50 or 77; Farm Management 75 (76); Poultry 50; Rural Engineering 75, 76; Horticulture 27, 75; Forestry 52; Market Gardening 50; Pomology 53; Mathematics (75), 77; Veterinary 78; other courses in the economics and the sociology departments bearing on rural problems.

Agricultural Economics. (Major.)

Professor Alexander E. Cance, *Adviser*.

[The heavy-faced type indicates the term in which the course is given.]

Course.	Number.	Credit.	Term.	Sophomore.	Credit.	Junior.	Credit.	Senior.	Credit.
Agricultural Economics, . . .	50 **I.**	5	**I.**			Agricultural Economics 50,	5	Agricultural Economics 75,	5
Agricultural Economics, . . .	52 **II.**	5							
Agricultural Economics, . . .	75 **I.**	5							
Agricultural Economics, . . .	76 **II.**		**II.**			Agricultural Economics 52,	5	Agricultural Economics 76,	5
or		5				Rural Sociology 51, . .	3	Rural Sociology 78, . .	5
Agricultural Economics, . . .	77 **III.**					Economic Sociology 51, .	5		
Economic Sociology, ...	51 **II.**	5							
Economic Sociology, ...	52 **III.**	5	**III.**			Economic Sociology 52, .	5	Farm Management 76, .	5
Farm Management, ...	76 **III.**	5				Rural Sociology 52, . .	3	Agricultural Economics 77,	5
Rural Sociology, ...	51 **II.**	3							
Rural Sociology, ...	52 **III.**	3	**IV.**						
Rural Sociology, ...	78 **II.**	5							
		46							

Additional Information. — The sophomore electives are left to the student to choose.

Agricultural Education. (Major.)

Professor William R. Hart, *Adviser*.

[The heavy-faced type indicates the term in which the course is given.]

Course.	Number.	Credit.	Term.	Sophomore.	Credit.	Junior.	Credit.	Senior.	Credit.
Agricultural Education,	50 **I.**	5	**I.**			Botany 50,	2	Agronomy 75,	5
Agricultural Education,	51 **II.**	5				Agricultural Education 50,	5	Poultry 50,	3
Agricultural Education,	52 **IV.**	5				Agronomy 50,	5	Dairying 77,	5
						Pomology 50,	3		
Agricultural Education,	53 **III.**	5	**II.**			Agricultural Education 51,	5	Farm Management 75,	3
Agronomy,	50 **I.**	5				Botany 51,	2		
Agronomy,	75 **I.**	5							
Botany,	50 **I.**	2	**III.**			Market Gardening 50,	3		
Botany,	51 **II.**	2				Agricultural Education 53,	5		
Dairying,	77 **I.**	5							
Farm Management,	75 **II.**	3	**IV.**			Agricultural Education 52,	5		
Market Gardening,	50 **III.**	3							
Pomology,	50 **I.**	3							
Poultry Husbandry,	50 **I.**	3							
		51							

Additional Information. — The sophomore electives allowed are left to the student to choose.

Substitutions of other technical courses for some of those above mentioned may be made to meet the needs of individual students.

A selection is allowed of Poultry Husbandry 50 and Market Gardening 50, making 6 credits, or Agronomy 75, 5 credits, making the total credits 45 or 46.

Rural Sociology. (Major.)

Professor John Phelan, *Adviser*.

[The heavy-faced type indicates the term in which the course is given.]

Course.	Number.	Credit.	Term.	Sophomore.	Credit.	Junior.	Credit.	Senior.	Credit.
Agricultural Economics,	50 **I.**	5	I.			Agricultural Economics 50,	5	Rural Sociology 75,	3
Agricultural Economics,	52 **II.**	5				Rural Sociology 50,	3	Economics and Sociology 75,	5
Economics and Sociology,	51 **II.**	5							
Economics and Sociology,	75 **I.**	5							
Economic Sociology,	76 **III.**	5	II.			Rural Sociology 51,	3	Rural Sociology 77,	3
Rural Journalism,	55 **III.**	3				Agricultural Economics 52,	5	Rural Sociology 78,	5
						Agricultural Education 52,	5		
						Economic Sociology 51,	5		
Rural Sociology,	50 **I.**	3	III.			Rural Journalism 55,	3	Rural Sociology 75,	3
Rural Sociology,	52 **III.**	3				Rural Sociology 52,	3	Economic Sociology 76,	5
Rural Sociology,	51 **II.**	3							
Rural Sociology,	77 **II.**	3	IV.						
Rural Sociology, or Rural Sociology,	75 **I.** or 75 **III.**	3							
Agricultural Education, or Rural Sociology,	52 **II.** or 78 **II.**	5							
		48							

Additional Information. — The sophomore electives allowed are left to the student to choose.

Description of Courses.

DIVISION OF AGRICULTURE.

Professor Foord.

[Heavy-faced Roman numerals indicate the term in which the course is given. Numbering of courses: 1 to 24, inclusive, freshmen; 25 to 49, inclusive, sophomores; 50 to 74, inclusive, juniors; 75 to 99, inclusive, seniors.]

Agronomy.

Assistant Professor Jones, Assistant Professor Abbott, Mr. Merkle, Mr. Cobb, Mr. Purington.

Required Course.

1. **I. and II.** Agronomy. — Freshman. Given as part of the freshman agriculture and horticulture. This course aims, by actual contact with the plants and their products, to make the student familiar with the most common farm crops of Massachusetts and their uses. The crops studied are maize, cereals, grasses, legumes, potatoes and root crops. Six weeks, part of class only, first term; balance of class, six weeks during the second term.
2 2-hour laboratory periods, credit, 1.
Assistant Professor Jones and Assistants.

27. **III.** Soils and Fertilizers. — Sophomores. A study of soils and their properties, soil management, methods of soil improvement and of maintenance of fertility, including the use of farm manures, commercial fertilizers and soil amendments.
4 class hours. 1 2-hour laboratory period, credit, 5.
The Department.
Prerequisite, freshman required Chemistry.

Elective Courses.

50. **I.** Field and Forage Crops. — For juniors; seniors may elect. History, classification and production of maize and of those grasses, legumes, forage and root crops suited to New England conditions. The work includes lecture, laboratory and field study of these various crops.
2 class hours. 3 2-hour laboratory periods, credit, 5.
Assistant Professor Jones and the Department.
Prerequisites, Agronomy 27, Botany 3.

51. **III.** Advanced Field Crops. — For juniors; seniors may elect. A study of the cereals and the minor farm crops not considered in Course 50. Laboratory work includes a study of the quality of seeds and grains, the grading and judging of farm crop products and field work with such crops as are available, especially mowings and pastures.
3 class hours. 2 2-hour laboratory periods, credit 5.
Assistant Professor Jones and the Department.
Prerequisite, Agronomy 50.

75. **I.** Advanced Soils. — For seniors; juniors may elect. A field, lecture and laboratory course on soils and their adaptability to different uses. The field work consists of a detailed study of soil textures, natural and spontaneous vegetation and other factors which indicate the fertility and adaptation of the soil; followed by a laboratory study of the physical properties of the soils sampled.
2 class hours. 3 2-hour laboratory periods, credit 5.
——————— and Mr. Merkle.
Prerequisite, Agronomy 27.

76. **III.** Drainage and Irrigation. — For seniors; juniors may elect. A field and lecture course on soil improvement by drainage and irrigation, with special reference to problems of this nature as faced by Massachusetts farmers.
2 class hours. 1 2-hour and 1 4-hour laboratory period, credit, 5.
The Department.
Prerequisites, Mathematics 26 and 27, Agronomy 27.

77. **II.** Manures and Fertilizers. — Seniors. An advanced course, giving a general discussion of the different theories which have been held relative to the functions and importance of manures and fertilizers, and leading up to the views at present accepted. Considerable attention is devoted to consideration of the experimental work which has been done, and which is now in progress. The laboratory work consists of a study of fertilizers, fertilizer mixtures, limes and water culture work.
4 class hours. 1 2-hour laboratory period, credit 5.
Assistant Professor Abbott.
Prerequisite, Agronomy 27.

78. **II.** Breeding of Field Crops. — Seniors. This course deals with the improvement, by selection and breeding, of the crops studied in Courses 50 and 51.
3 class hours.
Assistant Professor Jones.
Prerequisite, Agronomy 51.

Animal Husbandry.

Professor McNutt, Assistant Professor Quaife, Mr. Fish.

Required Course.

1. **I and II.** Animal Husbandry. — Freshman. Given as part of the freshman agriculture and horticulture. This course is outlined to give the student a greater appreciation of animal husbandry. Demonstrations will be given and judging will be done to familiarize the student with the various breeds and market classes. Six weeks, part of class only, first term; balance of class, six weeks during the second term.
2 2-hour laboratory periods, credit, 1.
Animal Husbandry Department.

Elective Courses.

25. **I.** Breeds and Types of Live Stock. — Sophomores. A course covering the origin, history, development and characteristics of the different breeds of horses, cattle, sheep and swine. Textbook, Plumb's "Breeds and Types of Farm Animals."
2 lectures. 1 2-hour laboratory period, credit, 3.
Assistant Professor Quaife.

26. **II.** Breeds and Types of Live Stock. — Sophomores. Continuation of Course 25.
2 lectures. 1 2-hour laboratory period, credit, 3.
Assistant Professor Quaife.
Prerequisite, Animal Husbandry 25.

50. **II.** Live Stock Management. — For juniors; seniors may elect. The work of this course consists of laboratory work by the individual students in the handling of live stock; with horses, such work as halter breaking, harnessing, casting and fitting for show will be done; similarly, the practical handling of cattle, sheep and swine will be fully treated. Special study is given to halter making, splicing, hitches, knots and all rope work.
1 2-hour laboratory period, credit, 1.
Assistant Professor Quaife.
Prerequisites, Animal Husbandry 25 and 26.

51. **III.** Principles of Breeding. — For juniors; seniors may elect. This course is designed to familiarize the student with the problems that are involved in animal improvement; to acquaint him with the facts which are already established; to scrutinize prevailing theories; and to indicate the lines and methods of further work. Some of the subjects studied are: variations, their causes and heritability; DeVrie's theory of mutations; the inheritance of acquired characters; the pure line; Mendelian law; the making of new types; the determination of sex; applications to human heredity. A few periods at the end of the course are devoted especially to the application of principles in live-stock improvement. "Genetics," by Herbert E. Walter. Supplementary reading.
3 class hours. Credit, 3.
Professor McNutt.
Prerequisite, Zoölogy 25.

52. **III.** Advanced Stock Judging. — For juniors; seniors may elect. This course is designed to equip animal husbandry students in the judging of classes of different types of live stock; to strengthen them in the selection of superior sires; and equip them for stock judging at fairs. Visits will be made to the best herds for the various breeds of stock in the State. Judging teams to represent the college will be selected from this class.
1 2-hour and 1 4-hour laboratory period, credit, 3.
Professor McNutt.
Prerequisite, Animal Husbandry 50.

75. **I.** Feeding and Management. — For seniors; juniors may elect. A study of the principles of animal nutrition; of the composition and qualities of feeding materials. Textbook, Henry's "Feeds and Feeding."
3 class hours. Credit, 3.
Assistant Professor Quaife.

Prerequisite, Chemistry 30 or 51.

76. **II.** Feeding and Management. — For seniors; juniors may elect. A study of the feeding, care and management of dairy cattle from birth to maturity, with especial attention to economic production. Textbook, Henry's "Feeds and Feeding."
3 class hours. Credit, 3.
Professor McNutt.

Prerequisite, Chemistry 30 or 51.

77. **III.** Feeding and Management. — For seniors; juniors may elect. A continuation of Courses 75 and 76, dealing in a similar manner with horses, sheep, beef cattle and swine.
3 class hours. Credit, 3.
Assistant Professor Quaife.

Prerequisite, Animal Husbandry 75.

78. **II.** Herd and Stud-book Study. — For seniors; juniors may elect. An advanced course in the study of the breeds of live stock, familiarizing the student with the detailed history of the breed, the most productive sires and dams of the various breeds, and the successful lines and methods of breeding.
1 class hour. 2 2-hour laboratory periods, credit, 3.
Professor McNutt.

Prerequisite, Animal Husbandry 75.

80. **III.** Seminar. — For seniors majoring in animal husbandry only. Advanced study upon questions pertaining to live stock and live-stock production. Each student electing this work will choose some particular line of work in which he is specially interested, and will pursue study in this subject by reading, compilation and research. There will be no regular lecture period, but seminars will be held. A satisfactory report of the results must be presented in a thesis.
1 2-hour laboratory period, credit, 1.
Professor McNutt.

Dairying.

Professor Lockwood, Assistant Professor Jamison, Mr. Coons, Mr. Drain.

Elective Courses.

50. **I.** Milk and Milk Composition. — For juniors; seniors may elect. The development of the dairy business in the United States; the composition, secretion and general characteristics of milk; contamination and fermentation; the study of analysis of milk products by use of the Babcock test for

fat, tests for acidity and adulteration, and ordinary preservatives; moisture tests for butter; methods for testing herds and developing them to higher efficiency; problems.
3 class hours. 2 2-hour laboratory periods, credit, 5.
Assistant Professor Jamison and the Department.

51. **III.** Butter Making. — For juniors; seniors may elect. A study of separators and cream separation; handling milk and cream for butter making; preparation of starters, and ripening cream; churning; markets and their requirements; marketing, scoring and judging butter; management; problems; dairy machinery and care thereof.
2 class hours. 2 3-hour laboratory periods, credit, 5.
Mr. Coons and the Department.
Prerequisite, Dairying 50.

75. **II.** Market Milk. — For seniors; juniors may elect. A study of market-milk conditions; extent and development of the business; supply and delivery; food value of milk and its uses as food; milk and its relation to the public health; proper methods for handling milk and cream for direct consumption; certified milk, requirements and production; pasteurizing; sterilizing; standardizing and modifying; milk laws and inspection.
3 class hours. 2 2-hour laboratory periods, credit, 5.
Professor Lockwood and the Department.
Prerequisite, Dairying 50.

76. **III.** Milk Products. — For seniors; juniors may elect. The manufacture of milk products other than butter, including cheddar cheese, soft and fancy cheese, ice cream, condensed milk, casein, milk powder, etc. Laboratories, largely the making of soft and fancy cheese and ice cream.
2 class hours. 2 3-hour laboratory periods, credit, 5.
Mr. Drain.
Prerequisite, Dairying 75.

77. **I.** Dairying. — For seniors; juniors may elect. A course designed primarily for teachers of secondary agriculture. The work given will cover briefly the composition and secretion of milk, the Babcock fat test, the relation of bacteria to dairy work and principles of creaming; separators; elementary butter making; proper methods of handling milk and cream; and the relation of market milk to the public health.
3 lecture hours. 2 2-hour laboratory periods, credit, 5.
Mr. Drain and the Department.

Farm Management.

Professor Foord, Mr. Peacock.

Elective Courses.

75. **II.** Farm Cost Accounting. — For seniors; juniors may elect. A study of farm inventories, single-enterprise accounts, complete farm accounts, and farm records. Special emphasis is given to the interpretation of results and their application in the organization and management of the farm.
1 class hour. 2 2-hour laboratory periods, credit 3.
Professor Foord, Mr. Peacock.

76. **III.** Farm Management. — For seniors; juniors may elect. The organization of the farm as a business enterprise. A discussion and study of some of the problems that confront the modern farmer, such as the choice of a farm, systems and types of farming, labor, marketing, records and farm accounts.

3 class hours. 2 2-hour laboratory periods, credit, 5.

Professor Foord.

Prerequisites, Agronomy 50, Animal Husbandry 25 and 26.

Poultry Husbandry.

Professor Graham, Dr. Goodale, Assistant Professor Payne, Mr. Rucker.

Required Course.

1. **I. and II.** Poultry Husbandry. — Freshman. Given as part of the freshman agriculture and horticulture. This course consists of a study of the characteristics of the most important breeds and varieties of poultry based upon the classification in the Standard of Perfection. This will embrace both standard and utility qualities. The work on comparison will be based on the key. A special score card will be used for utility judging. Attention will be given to the adaptation of the most popular varieties, to the more highly specialized lines of poultry culture, and to the part played by poultry in New England agriculture. Six weeks, part of class only, first term; balance of class, six weeks during the second term.

2 2-hour laboratory periods, credit, 1.

The Department.

Elective Courses.

50. **I.** Elements of Poultry Culture. — For juniors; seniors may elect. This course consists of a comprehensive study of opportunities in poultry culture, poultry-house construction, poultry-house equipment, feeds and feeding, winter-egg production, types and breeds of poultry.

3 class hours. Credit, 3.

Professor Graham, Assistant Professor Payne and Mr. Rucker.

51. **I.** Poultry Practice Work. — For juniors; seniors may elect. This is a practical laboratory course in poultry carpentry, caponizing, killing and picking; dressing and packing poultry; sorting and preparing eggs for market.

2 2-hour laboratory periods, credit, 2.

Assistant Professor Payne.

Prerequisite, must be accompanied by Poultry 50.

52. **II.** Elements of Poultry Culture. — For juniors; seniors may elect. This course treats the subjects of incubation, brooding, care of growing stock, breeding, market poultry, including capons, roasters and broilers, and diseases of poultry.

3 class hours. Credit, 3.

Assistant Professor Payne and Mr. Rucker.

Prerequisite, Poultry 50.

53. **III.** Incubation and Brooding. — For juniors; seniors may elect. In this course students are required to set up and operate incubators and brooders, make a systematic study of the development of the chick in the egg and the care of sitting hens. Laboratory time by arrangement.
1 class hour. 4 2-hour laboratory periods, credit, 5.
Assistant Professor Payne.

Prerequisite, Poultry 52.

54. **III.** Pen Management. — For juniors; seniors may elect. This is a practical laboratory course. Students are required to care for a pen of fowls, keeping accurate records of eggs produced, food consumed, weather conditions, health of fowls and profit and loss.
1 2-hour laboratory period, credit, 1.
Mr. Payne.

Prerequisite, Poultry 50.

55. **I., II. and III.** Investigational Work. — Seniors. This course is designed especially for students who are planning to do experiment station work. Students will be assigned specific problems to work out experimentally, or they may be required to assist in carrying on such work.
1 to 5 2-hour laboratory periods, credits, 1 to 5.
Dr. Goodale.

75. **II.** Poultry Management. — Seniors. A detailed study of large poultry farms and their equipment, such as bone cutters, feed cutters, cramming machines, etc.; the laying out and planning of poultry buildings of all kinds; mating of fowls. Attention to poultry diseases and investigation work carried on by experiment station is prominent. A few good poultry plants will be visited by the class for practical demonstrations.
5 class hours. Credit, 5.
Professor Graham.

Prerequisites, Poultry 53, 54, 76 and 77.

76. **I.** Advanced Poultry Judging. — Seniors. This course includes a study of the origin and history of breeds and varieties, poultry organizations and poultry shows. The American Standard of Perfection will be used as a text.
2 class hours. 3 2-hour laboratory periods, credit, 5.
Mr. Rucker.

Prerequisite, Poultry 53.

77. **I.** Market Poultry and Poultry Products. — Seniors. This course includes the study of market classifications of poultry, eggs and feathers, the requirements of different markets, methods of marketing, advantages and disadvantages of cold storage of poultry and eggs. Students will be required to fatten several lots of chickens by different methods and rations. Accurate data must be kept showing the gain in weight and quality, also the cost of feed, labor, etc., and the profit and loss. Judging and scoring of market poultry, both alive and dressed, and market eggs will be an important feature of this course.
2 class hours. 3 2-hour laboratory periods, credit, 5.
Assistant Professor Payne.

Prerequisites, Poultry 50, 51 and 52.

Rural Engineering.

Professor Gunness.

Elective Courses.

25. **I.** Carpentry. — For sophomores; juniors and seniors may elect. Practice in the use of tools by exercises in bench work, repair of farm equipment and farm building construction.

2 2-hour laboratory periods, credit, 2.
Rural Engineering Department.

26. **II.** Repair of Farm Equipment. — For sophomores; juniors and seniors may elect. Exercises in forge work, pipe fitting, soldering. Practice in the use of machinists' tools, such as file, cold chisel, drill press, taps and dies.

2 2-hour laboratory periods, credit, 2.
Rural Engineering Department.

75. **I.** Farm Structures. — For seniors; juniors may elect. Study of the strength, durability and cost of building materials; water supply; lighting and heating systems for the farm; drawing plans, writing specifications and estimating the cost of buildings; concrete construction as applied to foundations, silos, tanks, posts, floors and walks.

3 class hours. 2 2-hour laboratory periods, credit, 5.
Professor Gunness.

76. **I.** Farm Mechanics. — For seniors; juniors may elect. A general study of the farm equipment; farm buildings, their location, plan and arrangement; water supply; sewage disposal; lighting and heating systems; farm power and farm machinery. Course 76 has been planned for the benefit of those students who want a general course in farm mechanics but cannot spend the time to take the two courses 75 and 78.

3 class hours. 2 2-hour laboratory periods, credit, 5.
Professor Gunness.

77. **II.** Power Machinery. — For seniors; juniors may elect. Steam and gasoline engines, refrigerating machinery, electric motors and dynamos. Practice in pipe fitting, soldering, babbitting and fitting bearings, lacing belts and packing valves. Course 77 is intended primarily for dairy students, but would be valuable to any man who would expect to use engines, pumps or electrical machinery.

2 class hours. 3 2-hour laboratory periods, credit, 5.
Professor Gunness.

78. **III.** Farm Machinery. — For seniors; juniors may elect. Study of the care and operation of tillage, seeding, harvesting, pumping and spraying machinery; steam and gas engines. Special attention will be given to the use of power on the small farm. Practice in the adjustment of the various machines, babbitting and fitting bearings, lining shafts and pulleys, lacing belts, splicing rope and packing valves.

2 class hours. 3 2-hour laboratory periods, credit, 5.
Professor Gunness.

DIVISION OF HORTICULTURE.

Professor Waugh, Assistant Professor Thompson, Assistant Professor Wheeler.

[The general subject of horticulture divides naturally into subjects of pomology, floriculture, forestry, landscape gardening and market gardening. A number of courses relate to more than one of these subjects, and are therefore grouped here under the general designation of horticulture.]

Required Course.

1. **I. and II.** Horticulture. — Freshman (part of freshman agriculture and horticulture). A general introduction to horticulture; principally laboratory work, judging fruits, etc., in class and field. Six weeks with class divided between first and second terms.

2 2-hour laboratory periods, credit, 1.
Assistant Professor Wheeler.

Elective Courses (General).

27. **III.** Nursery Practice. — For sophomores; juniors and seniors may elect. This course treats of the fundamental methods of plant propagations by seeds, cuttings, budding, grafting, etc. Lectures and practicums.
2 class hours. 1 2-hour laboratory period, credit, 3.
Assistant Professor Thompson.

50. **I.** Plant Materials. — For juniors; seniors may elect. This course aims to make the student familiar with the character of the trees, shrubs and herbaceous perennials used in ornamental work, and with the methods of propagating them.
3 class hours. 2 2-hour laboratory periods, credit, 5.
Assistant Professor Thompson.
Prerequisite, Horticulture 27.

51. **III.** Plant Materials. — For juniors; seniors may elect. A continuation of Course 50, taking up the field use of trees, shrubs and herbaceous plants, their native habitats, soils and plant associations, with a view to supplying to students in landscape gardening and floriculture a knowledge of plant species. Frequent practicums and field excursions.
3 class hours. 2 2-hour laboratory periods, credit, 5.
Assistant Professor Thompson.
Prerequisite, Horticulture 50.

75. **I.** Plant Breeding. — For seniors and graduate students. [Not given in 1917-18.] This course is designed to introduce advanced students to the best modern views of variation, heredity and evolution, and to the best methods of studying the phenomena found in these subjects. The principles educed apply to both animal breeding and plant breeding, but the laboratory work (of which there is considerable) is concerned chiefly with plant life. Some practice work in hybridization and selection is undertaken, and students

are trained as far as possible in the practical application of those principles which have direct bearing on the breeding of plants and the cultivation of crops.
3 class hours. 2 2-hour laboratory periods, credit, 5.

Prerequisite, open only to students well prepared in agricultural or horticultural subjects.

Floriculture.

Associate Professor Nehrling, Mr. Wildon.

Elective Courses.

50. **I.** Greenhouse Management. — For juniors; seniors may elect. This course is designed to familiarize students with the methods followed in the management of greenhouse crops. The students are instructed in the practical operations of watering, potting, fumigating, ventilating and in the methods of propagation of plants by seed and cuttings. They will also be expected to arrange their hours according to the needs of the work.
2 class hours. 1 4-hour laboratory period, credit, 4.
Associate Professor Nehrling and Mr. Wildon.
Prerequisite, Horticulture 27.

51. **II.** Greenhouse Management. — For juniors; seniors may elect. Continuation of Course 50. In addition, work in the use of cut flowers and plants in decorative work, the arrangement of flowers in baskets, designs, vases, table and home decorations will be considered.
2 class hours. 1 4-hour laboratory period, credit, 4.
Associate Professor Nehrling and Mr. Wildon.
Prerequisite, Floriculture 50.

52. **III.** Greenhouse Management. — For juniors; seniors may elect. A continuation of Courses 50 and 51.
2 class hours. 1 4-hour laboratory period, credit, 4.
Associate Professor Nehrling and Mr. Wildon.
Prerequisite, Floriculture 51.

53. **I.** Greenhouse Construction. — For juniors; seniors may elect. The location, arrangement, construction, cost, heating and ventilating of greenhouse structures; also the drawing of plans and drafting of specifications for commercial houses and private ranges. Such practical work as glazing, the construction of concrete benches and cold frames will be included in this course.
2 class hours. 1 2-hour laboratory period, credit, 3.
Associate Professor Nehrling and Mr. Wildon.
Prerequisite, should be taken with Floriculture 50.

54. **II.** Greenhouse Construction. — For juniors; seniors may elect. A continuation of Course 53.
2 class hours. 1 2-hour laboratory period, credit, 3.
Associate Professor Nehrling and Mr. Wildon.
Prerequisite, Floriculture 53.

75. **I.** Commercial Floriculture. — Seniors. A detailed study will be made of the methods of culture for greenhouse plants and cut flowers for wholesale and retail markets. The care and marketing of all florists' crops will also be considered. Assigned readings on these topics.
2 class hours. 1 2-hour laboratory period, credit, 3.
Associate Professor Nehrling.

Prerequisite, Floriculture 52.

76. **III.** Commercial Floriculture. — Seniors. As stated under Course 75.
2 class hours. 1 2-hour laboratory period, credit, 3.
Associate Professor Nehrling.

Prerequisites, Floriculture 75 and 80.

77. **II.** Conservatory Work and Decorative Plants. — Seniors. A study of the tropical and subtropical foliage and flowering plants used in conservatory work. Their arrangement and care will also be considered. Assigned readings.
2 class hours. 1 2-hour laboratory period, credit, 3.
Associate Professor Nehrling.

Prerequisite, Floriculture 75.

78. **III.** Garden Flowers and Bedding Plants. — Juniors and seniors. This course aims to make the student familiar with those annuals, herbaceous perennials, bulbs and bedding plants used in landscape work. Their propagation, culture and uses will be considered. Assigned readings and field trips.
2 class hours. 1 2-hour laboratory period, credit, 3.
Associate Professor Nehrling and Mr. Wildon.

79. **III.** Seminar. — For seniors majoring in floriculture only. Advanced study of subjects pertaining to commercial floriculture or private garden work. All students electing this work will be assigned a specific problem, and will pursue study in these problems by reading and research. No regular lectures will be given, but seminars will be conducted each week. A satisfactory report of the results must be presented.
2 to 6 laboratory hours. Not to exceed 3 credits.
Associate Professor Nehrling.

80. **II.** Commercial Floriculture. — Seniors. As stated under Course 75.
2 class hours. 1 2-hour laboratory period, credit, 3.
Associate Professor Nehrling and Mr. Wildon.

Prerequisite, Floriculture 75.

Forestry.

Professor CLARK.

Elective Courses.

50. I. DENDROLOGY. — For juniors; seniors may elect. During the first part of the term frequent field trips will be made to identify and study the habits of our native forest trees. Later, the classification, range, distribution, forest habits, quality, uses and identification of wood of the commercial timber trees of the United States will be studied. Lectures, recitations, laboratories or field work at option of instructor.

3 2-hour laboratory periods, credit, 3.
Professor CLARK.

51. II. WOOD TECHNOLOGY. — For juniors; seniors may elect. A study of the commercial woods found in the lumber markets, methods of identification, uses, strength values, technical qualities, decay and methods of preservation.

1 class hour. 2 2-hour laboratory periods, credit, 3.
Professor CLARK.

52. III. PRINCIPLES OF FORESTRY. — For juniors; seniors may elect A lecture course for the purpose of giving the students a general view of the whole field of forestry and what forestry attempts to accomplish and has accomplished. Not required of students who propose to major in forestry.

2 class hours. Credit, 2.
Professor CLARK.

53. III. SILVICULTURE. — For juniors; seniors may elect. Factors influencing forest growth; forest types; silvicultural systems; care and protection of forests; forest description; forest nursery practice and forest planting.

1 class hour. 1 4-hour laboratory period, credit, 3.
Professor CLARK.

Prerequisite, Forestry 50.

54. IV. ARBORICULTURE. — For juniors; seniors may elect. A course dealing with problems of shade tree propagation, protection and repair; the choice and grouping of species; shade tree laws. Assigned readings.

120 hours' field work, credit, 5.
Professor CLARK.

75. I. FOREST MENSURATION. — For seniors; juniors may elect. Methods of determining the volume of trees, logs and entire forests. Methods of computing volume tables, tree and forest growth and yield tables. Timber estimating.

3 class hours. 72 hours' field work, credit, 5.
Professor CLARK.

78. III. SEMINAR — REPORT. — Seniors. This may involve research, laboratory or field work in the investigation of some subject, together with a

review of the literature relating to it and an original written report evidencing the results. Subject to be chosen in conference with Professor Clark.

6 laboratory hours, credit, 3.
Professor CLARK.

Landscape Gardening.

Professor WAUGH, Assistant Professor HARRISON.

Elective Courses.

50. **I.** ELEMENTS OF LANDSCAPE GARDENING. — Juniors. Reconnoissance surveys and mapping, with special reference to the methods used in landscape gardening; detailed study of selected designs of leading landscape gardeners; grade design, road design and field work. Must be followed by Course 51.

2 2-hour laboratory periods; 2 3-hour laboratory periods, credit, 5.
Professor WAUGH.

Prerequisites, Mathematics 25 and 26, Drawing 25, 26 and 27, Horticulture 27.

51. **II.** ELEMENTS OF LANDSCAPE GARDENING. — Juniors. As stated under Course 50.

3 3-hour laboratory periods, credit, 4.
Assistant Professor HARRISON.

Prerequisite, Landscape Gardening 50.

52. **III.** GENERAL DESIGN. — Juniors. Field notes; examination of completed works and those under construction; design of architectural details, planting plans, gardens, parks and private grounds; written reports on individual problems. Must be followed by Course 53.

2 2-hour laboratory periods; 2 3-hour laboratory periods, credit, 5.
Assistant Professor HARRISON.

Prerequisites, Landscape Gardening 50 and 51, and either plant materials (Horticulture 50 and 51) or advanced mathematics.

53. **IV.** (Summer.) GENERAL DESIGN. — Juniors. As stated under Course 52.

120 laboratory hours, credit, 5.
Assistant Professor HARRISON.

Prerequisite, Landscape Gardening 52.

75. **I.** THEORY OF LANDSCAPE ART. — For seniors and graduates. The general theory and applications of landscape study, including a biief history of the art.

3 class hours. Credit, 3.
Professor WAUGH.

76. **II.** CIVIC ART. — Seniors. The principles and applications of modern civic art, including city planning, city improvement, village improvement and rural improvement, with special emphasis upon country planning. Must be followed by Course 77.

3 3-hour laboratory periods, credit, 4.
Professor WAUGH.

Prerequisite, Landscape Gardening 53.

77. **III.** Civic Art. — Seniors. As stated under Course 76.
3 3-hour laboratory periods, credit, 4.
Professor Waugh.

Prerequisite, Landscape Gardening 76.

78. **III.** Architecture. — Alternating with Course 79; given in 1916-17. Juniors and seniors. The history of architectural development, the different historic types, with special reference to the underlying principles of construction and design and their relations to landscape design. Illustrated lectures, conferences, practice in designing.
3 class hours. Credit, 3.
Assistant Professor Harrison.

79. **III.** Construction and Maintenance. — Alternating with Course 78; given in 1917-18. Juniors and seniors. Detailed instruction in methods of construction and planting in carrying out plans, in organization, reporting, accounting, estimating, etc.; maintenance work in parks and on estates, its organization, management, cost, etc.
3 class hours. Credit, 3.
Assistant Professor Harrison.

Market Gardening.

Professor Tompson, Assistant Professor Thomson.

Elective Courses.

50. **III.** Elements of Market Gardening. — Juniors; seniors may elect. A study of the business of commercial vegetable growing to acquaint the student with the fundamental considerations of the business and a knowledge of the market-garden crops. The study of the crops will consist of class-room, laboratory and field work, dealing with propagation, cultivation and marketing. Text and reference books.
3 class hours. 2 2-hour laboratory periods, credit, 5.
Assistant Professor Thomson.

75. **I.** Elements of Market Gardening. — Seniors. A continuation of Market Gardening 50. A systematic study of types, varieties and strains of the leading vegetable crops, as well as a study of the problems of farm planning, irrigation, crop rotation, spraying, storage and methods of marketing and seed production. Text and reference books. Occasional seminars. Laboratory and field work.
3 class hours. 2 2-hour laboratory periods, credit, 5.
Assistant Professor Thomson.

Prerequisite, Market Gardening 50.

76. **II.** Greenhouse Vegetable Growing. — Seniors. A study of the production of vegetables under glass as a business, briefly considering economic reasons for its development, progress in methods and management and the present status of the industry. A study of vegetable-forcing house construction, heating and greenhouse management, as applied to the leading green-

house crops, lettuce, cucumbers and tomatoes, with proportionate time given to the crops of lesser importance. Text and reference books and periodicals. Greenhouse work in actual production and management is a part of this course, and the student must so arrange that he can give it adequate attention. Considerable seminar work.
3 class hours. 2 2-hour laboratory periods, credit, 5.
Assistant Professor Thomson.

Prerequisite, Market Gardening 75.

Pomology.

Professor Sears, Associate Professor Chenoweth.

Elective Courses.

50. **I.** Practical Pomology. — For juniors; seniors may elect. A study of the general principles of the growing of fruits, dealing with such questions as selection of site, soils, windbreaks, laying out plantations, choice of nursery stock, pruning, culture of orchards, orchard fertilizers, cropping orchards, etc. Lectures, supplemented with text and reference books; field and laboratory exercises.
2 class hours. 1 2-hour laboratory period, credit, 3.
Professor Sears.

Prerequisite, Horticulture 27.

51. **II.** Practical Pomology. — For juniors; seniors may elect. As stated under Course 50.
2 class hours. 1 2-hour laboratory period, credit, 3.
Professor Sears.

Prerequisite, Pomology 50.

52. **III.** Practical Pomology. — For juniors; seniors may elect. As stated under Course 50.
2 class hours. 1 2-hour laboratory period.
Professor Sears.

Prerequisite, Pomology 51.

53. **IV.** (Summer.) Small Fruits. — For juniors; seniors may elect. The growing, harvesting, marketing and storing of small fruits, including currants, gooseberries and grapes, together with thinning, spraying, picking and marketing of tree fruits at the college orchards and in private commercial orchards.
120 laboratory hours, credit, 5.
Associate Professor Chenoweth.

75. **I.** Systematic Pomology. — Seniors. A study of the varieties of the different fruits and of nomenclature, with critical descriptions; special reference being given to relationships and classification. Lectures, laboratory and field exercises.
1 class hour. 2 2-hour laboratory periods, credit, 3.
Associate Professor Chenoweth.

Prerequisite, Pomology 52.

76. **II.** Systematic Pomology. — Seniors. As stated under Course 75.
1 class hour. 2 2-hour laboratory periods, credit, 3.
Associate Professor Chenoweth.
Prerequisite, Pomology 75.

77. **I.** Commercial Pomology. — Seniors only, majoring in pomology. The picking, handling, storing and marketing of fruits, including a discussion of storage houses, fruit packages, methods of grading and packing, manufacturing, etc. Especial emphasis is placed upon laboratory and field work, where the student is given actual practice in the picking and packing of all the principal fruits, together with the manufacture of by-products.
1 class hour. 2 2-hour laboratory periods, credit, 3.
Associate Professor Chenoweth.
Prerequisite, Pomology 52.

78. **III.** Spraying. — Seniors. A study of (*a*) spraying materials, their composition, manufacture and preparation for use; the desirable and objectionable qualities of each material, formulas used, cost, tests of purity. (*b*) Spraying machinery, including all the principal types of pumps, nozzles, hose and vehicles; their structure and care. (*c*) Orchard methods in the application of the various materials used, with the important considerations for spraying each fruit and for combating each orchard pest. This course is designed especially to familiarize the student with the practical details of actual spraying work in the orchard. Spray materials are prepared, spraying apparatus is examined and tested, old pumps are overhauled and repaired, and the actual spraying is done in the college orchards and small-fruit plantations.
1 class hour. 2 2-hour laboratory periods, credit, 3.
Professor Sears.
Prerequisite, Pomology 52.

79. **III.** General Pomology. — For seniors; juniors may elect. This course is planned to meet the needs of those students who cannot devote more than one term to the subject but who want a general knowledge of fruit growing. The work will consist of lectures and laboratory exercises on such topics as choosing the locations, kinds and varieties of fruits to grow, securing and setting the plants, care and cultivation, pruning, spraying, pests, harvesting and storing.
2 lectures. 1 2-hour laboratory period, credit, 3.
Associate Professor Chenoweth.

80. **I.** Seminar. — For seniors majoring in pomology. Advanced study of problems relating to the business of fruit growing. Each student will be assigned a major and a minor problem in lines of work in which he is particularly interested. He will pursue his studies both by reading and research, and the materials obtained will be worked into theses which will be presented to the seminar for discussion. Reports on minor problems will be taken up first. No lectures will be given, but seminar meetings will be held for one period each week.
Credit, 1.
Professor Sears and Associate Professor Chenoweth.

81. **II.** Seminar. — For seniors majoring in pomology. A continuation of Course 80. One seminar meeting each week.

Credit, 1.

Professor Sears and Associate Professor Chenoweth.

82. **III.** Seminar. — For seniors majoring in pomology. A continuation of Course 81. One seminar meeting each week.

Credit, 1.

Professor Sears and Associate Professor Chenoweth.

Drawing.

Mr. Root.

Elective Courses.

25. **I.** Free-hand Drawing. — For sophomores; juniors and seniors may elect. Lettering; free-hand perspective; sketching from type models, leaves, flowers and trees, houses, etc.; laying flat and graded washes in water colors; water-color rendering of leaves, flowers and trees; conventional coloring and map rendering in water colors; conventional signs and mapping in ink.

3 2-hour laboratory periods, credit, 3.

Mr. Root.

26. **II.** Mechanical Drawing. — For sophomores; juniors and seniors may elect. Inking exercises; geometric problems; projection; intersections, isometric; shades and shadows; parallel; angular and oblique perspective; perspective drawing of buildings. Students should have preparation in plane and solid geometry.

3 2-hour laboratory periods, credit, 3.

Mr. Root.

27. **III.** Mechanical Drawing. — For sophomores; juniors and seniors may elect. As stated under Course 26.

3 2-hour laboratory periods, credit, 3.

Mr. Root.

Prerequisite, Drawing 26.

DIVISION OF SCIENCE.

Botany.

Professor OSMUN, Associate Professor ANDERSON, Assistant Professor CLARK, Mr. McLAUGHLIN, Mr. MARTIN, Mr. WHITE, Mr. MARDFIN.

[Heavy-faced type indicates the term in which the course is given. Numbering of courses: 1 to 24, inclusive, freshmen; 25 to 49, inclusive, sophomores; 50 to 74, inclusive, juniors; 75 to 99, inclusive, seniors.]

Required Courses.

3. **III.** MORPHOLOGY AND TAXONOMY OF THE HIGHER PLANTS (PHANEROGAMIA). — Freshmen. Seeds and seedlings; types of leaves, stems, roots and flowers. Determination and naming of plants, using Gray's "New Manual of Botany." An herbarium of 75 species of plants is required of each student.
1 class hour. 2 2-hour laboratory periods, credit, 3.
Professor OSMUN, Mr. McLAUGHLIN, Mr. MARTIN, Mr. WHITE, Mr. MARDFIN.

25. **I.** ANATOMY, PHYSIOLOGY AND ECOLOGY OF THE HIGHER PLANTS. — Sophomores. Structure, functions, metabolism and environmental relations of seed plants.
1 class hour. 2 2-hour laboratory periods, credit, 3.
Professor OSMUN, Mr. McLAUGHLIN, Mr. MARTIN, Mr. WHITE, Mr. MARDFIN.
Prerequisite, Botany 3.

Elective Courses.

26. **II.** MORPHOLOGY AND TAXONOMY OF THE LOWER PLANTS (CRYTOGAMIA). — Sophomores. Systematic study of typical forms of bacteria, algae, fungi, lichens, mosses, ferns. (Courses 3, 25 and 26 constitute a general elementary course in botany, and are prerequisites of all subsequent work taken in the Department of Botany.)
1 class hour. 2 2-hour laboratory periods, credit, 3.
Professor OSMUN, Mr. McLAUGHLIN, Mr. MARTIN, Mr. WHITE, Mr. MARDFIN.
Prerequisite, Botany 25.

50. **I.** DISEASES OF CROPS. — For juniors; seniors may elect. Laboratory and recitations devoted to diseases of the special crops related to the student's major. Arranged in sections for students specializing in (1) agronomy or market gardening; (2) floriculture or landscape gardening; (3) forestry or pomology; (4) entomology. Students may take the laboratory work in one, two or three sections. The laboratory work for students in entomology is general, and includes the more important diseases studied in the other sections. The class is not sectioned for lectures, which are general.
1 class hour. 1, 2 or 3 2-hour laboratory periods, credits, 2, 3 or 4.
Mr. MARTIN, Mr. McLAUGHLIN.
Prerequisite, Botany 26.

51. **II.** Diseases of Crops. — For juniors; seniors may elect. As stated under Course 50.
1 class hour. 1, 2 or 3 2-hour laboratory periods, credits, 2, 3 or 4.
Mr. Martin, Mr. McLaughlin.
Prerequisite, Botany 50.

52. **I.** Systematic Mycology. — For juniors; seniors may elect. Morphology and development of typical species representing the orders and families of fungi; practice in identification, collection and preservation of fungi; study of systems of classification; collateral reading. A prerequisite of the senior course in plant pathology, but open to all.
1 class hour. 2 2-hour laboratory periods, credit, 3.
Associate Professor Anderson.
Prerequisite, Botany 26.

53. **II.** Systematic Mycology. — For juniors; seniors may elect. As stated under Course 52.
1 class hour. 2 2-hour laboratory periods, credit, 3.
Associate Professor Anderson.
Prerequisite, Botany 52.

54. **III.** Systematic Mycology. — For juniors; seniors may elect. As stated under Course 52.
1 class hour. 2 2-hour laboratory periods, credit, 3.
Associate Professor Anderson.
Prerequisite, Botany 53.

55. **I.** Plant Histology. — For juniors; seniors may elect. Comparative study of the tissues of plants; training in histological methods, including the use of precision microtomes, methods of killing, fixing, sectioning, staining and mounting; collateral reading and conferences. This course offers valuable training in preparation for further work in botany.
1 class hour. 2 2-hour laboratory periods, credit, 3.
Professor Osmun, Mr. McLaughlin.
Prerequisite, Botany 26.

56. **II.** Plant Histology. — For juniors; seniors may elect. As stated under Course 55.
1 class hour. 2 2-hour laboratory periods, credit, 3.
Professor Osmun, Mr. McLaughlin.
Prerequisite, Botany 55.

75. **I.** Plant Pathology. — Seniors. Comprehensive study of diseases of plants; training in laboratory methods and technique, including culture work and artificial inoculation of hosts; miscellaneous diagnosis; study of literature and representative life histories of pathogens. Prepares for civil service, experiment station and college work.
1 class hour. 4 2-hour laboratory periods, credit, 5.
Professor Osmun and Associate Professor Anderson.
Prerequisite, Botany 54.

76. **II.** Plant Pathology. — Seniors. As stated under Course 75.
1 class hour. 4 2-hour laboratory periods, credit, 5.
Professor Osmun and Associate Professor Anderson.
Prerequisite, Botany 75.

77. **III.** Plant Pathology. — Seniors. As stated under Course 75.
1 class hour. 4 2-hour laboratory periods, credit, 5.
Professor Osmun and Associate Professor Anderson.
Prerequisite, Botany 76.

78. **I.** Plant Physiology. — Seniors. A general course dealing with such topics as absorption, nutrition, growth and movements of plants; training in laboratory methods and the use of apparatus; collateral reading.
2 class hours. 3 2-hour laboratory periods, credit, 5.
Assistant Professor Clark.
Prerequisites, Botany 26 and Chemistry 51.

79. **II.** Plant Physiology. — Seniors. As stated under Course 78.
2 class hours. 3 2-hour laboratory periods, credit, 5.
Assistant Professor Clark.
Prerequisite, Botany 78.

80. **III.** Plant Physiology. — Seniors. As stated under Course 78.
2 class hours. 3 2-hour laboratory periods, credit, 5.
Assistant Professor Clark.
Prerequisite, Botany 79.

82. **II.** Cytology and Embryology. — Seniors. Morphology and physiology of the cell; cell-division; embryonal development.
1 class hour. 2 2-hour laboratory periods, credit, 3.
Mr. McLaughlin.
Prerequisites, Botany 26 and 55.

83. **III.** Cytology and Embryology. — Seniors. As stated under Course 82.
1 class hour. 2 2-hour laboratory periods, credit, 3.
Mr. McLaughlin.
Prerequisite, Botany 82.

86. **I.** Seminar. — For seniors and graduate students. Presentation and discussion of important current botanical papers. A major requirement.
1 class hour. Credit, 1.
The Department.

87. **II.** Seminar. — For seniors and graduate students. As stated under Course 86.
1 class hour. Credit, 1.
The Department.

88. **III.** Seminar. — For seniors and graduate students. As stated under Course 86.
1 class hour or 2 laboratory hours. Credit, 1.
The Department.

General and Agricultural Chemistry.

Professor Lindsey, Professor Wellington, Professor Chamberlain, Professor Peters, Professor Anderson, Mr. Serex, Mr. Beebe, Mr. Kelly, Mr. MacNeil, Mr. Perry, Mr. A. L. Prince.

[The course in chemistry aims to teach accurate observation, logical thinking and systematic and constant industry. It likewise aims to give those students following the several agricultural occupations, or who are preparing themselves for work as teachers and investigators in the other sciences, a knowledge of the subject sufficient to enable them to apply it in their various lines of work. Students taking all of the undergraduate courses and intending to follow chemistry as a vocation are prepared for positions as instructors in high schools and colleges, in the agricultural experiment stations, the United States Department of Agriculture, as well as in fertilizer, cattle food, sugar and dairy industries. Students are encouraged to take especially graduate work leading to the degree of Master of Science, and to thus prepare themselves for advanced positions as teachers in the agricultural colleges, as research chemists, and likewise for the more responsible positions connected with the different agricultural industries of the country. A fuller knowledge of the course of instruction will be found by consulting the following outline.]

Required Courses.

1. **I.** General Chemistry. — Freshmen. An introduction to the fundamental chemical laws, together with a study of the common acid-forming elements and their compounds. Textbook, Kahlenberg's "Outlines of Chemistry." This course is for those students who do not present chemistry for entrance, and who begin the subject in college.
2 class hours. 1 2-hour laboratory period, credit, 3.
Professor Peters, Mr. Serex, Mr. Beebe and Mr. Prince.

2. **II.** General Chemistry. — Freshmen. A continuation of Course 1. A study of metals and their compounds. The laboratory work is the same as described under Course 4.
2 class hours. 1 2-hour laboratory period, credit, 3.
Professor Peters and Assistants.

3. **III.** Inorganic Agricultural Chemistry. — Freshmen. As stated under Course 5 **II.**
2 class hours. 1 2-hour laboratory period, credit, 3.
Professor Anderson and Assistants.

4. **I.** Advanced General Chemistry. — Freshmen. A review of the fundamental chemical laws, together with the common acid and base-forming elements and their compounds. Textbook, Kahlenberg's "Outlines of Chemistry." The laboratory work takes the synthetic form. Substances of agricultural importance are prepared in quantity and studied in detail by the student. These include ammonium sulfate, superphosphate, muriate and sulfate of potash, arsenate of lead, Paris green, Bordeaux mixture, lime-sulfur and emulsions.
2 class hours. 1 2-hour laboratory period, credit, 3.
Professor Anderson and Assistants.
Prerequisite, Entrance Chemistry.

5. **II.** Inorganic Agricultural Chemistry. — Freshmen. A study of the chemical composition, properties and reactions of soils, fertilizers, fungicides and insecticides. The laboratory work is divided into three parts, as

follows: (*a*) qualitative examination of soil, plant ash and superphosphate; (*b*) approximate quantitative determination of moisture, ash, carbonic acid, phosphoric acid, potash, etc.; (*c*) special work on retention of salts by soil, leaching of lime from the soil by carbonated water, etc.

2 class hours. 1 2-hour laboratory period, credit, 3.
Professor ANDERSON and Assistants.

Prerequisite, Chemistry 3 or 4.

6. **III.** ORGANIC AGRICULTURAL CHEMISTRY. — Freshmen. As stated in Course 30.

2 class hours. 1 2-hour laboratory period, credit, 3.
Professor CHAMBERLAIN and Assistants.

Prerequisites, Chemistry 4 and 5.

Elective Courses.

25. **I.** QUALITATIVE ANALYSIS. — *Basic.* — Sophomores. A course in the systematic analysis of metallic salts, presented from the ionic viewpoint. The student studies closely the tests used in the separation and identification of the metals; he then applies these tests to unknown mixtures. Text, Medicus' "Qualitative Analysis," with Böttger's "Qualitative Analysis" and Treadwell-Hall's "Qualitative Analysis" for reference. This course should be taken, particularly, by all intending to follow chemistry as a vocation.

1 class hour. 2 2-hour laboratory periods, credit, 3.
Professor ANDERSON and Mr. KELLY.

Prerequisite, Chemistry 3 or 6.

26. **II.** QUALITATIVE ANALYSIS. — *Acidic.* — Sophomores. A continuation of Course 25. A large part of the term is spent in the examination qualitatively of minerals and of agricultural products.

1 class hour. 2 2-hour laboratory periods, credit, 3.
Professor ANDERSON and Mr. KELLY.

Prerequisite, Chemistry 25.

27. **III.** QUANTITATIVE ANALYSIS. — For sophomores; juniors and seniors may elect. Instruction in this course includes the gravimetric and volumetric determinations of some of the commoner metals and non-metals. Talbot's "Quantitative Chemical Analysis" is used as a text.

1 class hour. 2 4-hour laboratory periods, credit, 5.
Professor WELLINGTON, Professor PETERS and Mr. MACNEIL.

Prerequisite, Chemistry 25. Course 26 is prerequisite for those majoring in chemistry.

30. **III.** ORGANIC AGRICULTURAL CHEMISTRY. — For sophomores; juniors and seniors may elect. The course embraces the study of the most important groups of organic compounds of plants and animals, the composition of plants, the chemistry of plant growth, plants as food and as industrial material, the composition of animals, the chemistry of digestion, also the study of some of the products related to plants and animals, such as milk, butter, cheese, sugar, alcohol, wood pulp and paper. The treatment of the subject will be

general, avoiding (so far as possible) complicated chemical facts and relationships, and endeavoring simply to make the student acquainted with the general chemistry of plants and animals and agricultural processes and products.
3 class hours. 2 2-hour laboratory periods, credit, 5.
Professor Chamberlain and Mr. Perry.
Prerequisite, Chemistry 3 or 6.

51. I. Organic Chemistry. — For juniors; seniors may elect. This course is designed especially: (1) for those who are looking forward to positions as chemists in agricultural colleges or experiment stations, the United States Department of Agriculture, or similar places, and who need a knowledge of chemistry for itself; and (2) for those who are expecting to enter like positions in other sciences, and who will use their knowledge of chemistry in a secondary way. It consists of a systematic study, both from texts and in the laboratory, of the more important compounds in the entire field of organic chemistry. Especial attention is given to those compounds which are found in agricultural products or are manufactured from them. These include alcohols, acids, esters, fats, carbohydrates, proteins, etc. The work forms a foundation for courses in physiological chemistry and agricultural analysis, and thus for future work in agricultural chemical investigation. Those electing Course 51 are expected to elect Course 52.
5 class hours. 2 3-hour laboratory periods, credit, 8.
Professor Chamberlain and Mr. Perry.
Prerequisites, Chemistry 3 or 6, and Chemistry 27 for those majoring in chemistry.

52. II. Organic Chemistry. — For juniors; seniors may elect. As stated under Course 51.
5 class hours. 2 3-hour laboratory periods, credit, 8.

Prerequisite, Chemistry 51.

60. I. Advanced Quantitative Chemistry. — For juniors; seniors may elect. Advanced work on subjects as stated under Course 27.
1 class hour. 1 4-hour laboratory period, credit, 3.
Professor Wellington, Professor Peters and Mr. MacNeil.
Prerequisite, Chemistry 27.

61. II. Insecticide Analysis. — For juniors; seniors may elect. A study of methods for the analysis of insecticides. (For 1916–17 only, 2 4-hour laboratory periods, credit 5.)
1 class hour. 1 4-hour laboratory period, credit, 3.
Professor Wellington, Professor Peters and Mr. MacNeil.
Prerequisite, Chemistry 27.

62. III. Soil and Fertilizer Analyses. — For juniors; seniors may elect. A study of methods for analyses of soils and fertilizers.
1 class hour. 2 4-hour laboratory periods, credit, 5.
Professor Wellington, Professor Peters and Mr. MacNeil.
Prerequisite, Chemistry 27.

65. **III.** Physical Chemistry. — For juniors; seniors may elect. A résumé of general chemistry from the viewpoint of physical chemistry, and the application of physical chemistry to agricultural chemistry.
3 class hours. 2 2-hour laboratory periods, credit, 5.
Professor Anderson and Mr. Kelly.
Prerequisite, Chemistry 27.

76. **I.** Milk and Butter Analysis. — For seniors; juniors may elect. A study of chemical methods of analysis of milk and butter.
1 class hour. 2 4-hour laboratory periods, credit, 5.
Professor Peters and Mr. MacNeil.
Prerequisite, Chemistry 27.

77. **II.** Cattle Feed, Water and Miscellaneous Analysis. — For seniors; juniors may elect. A study of methods of analysis of cattle feeds and water, with interpretations. Other materials may be analyzed.
1 class hour. 1 4-hour laboratory period, credit, 3.
Professor Peters and Mr. MacNeil.
Prerequisite, Chemistry 27.

80. **I.** Physiological Chemistry. — Seniors. This course is intended to be supplementary to Courses 51 and 52, and Course 30. To those who expect to take up scientific work in microbiology, botany, agronomy, animal husbandry, etc., and who have had Courses 51 and 52, it will give acquaintance with the chemistry of the physiological processes in plants and animals, by means of which some of the important organic compounds studied in Courses 51 and 52 are built up in the living organism or are used as food by it. In the lectures the study of food and nutrition as related to both human and domestic animals is the principal subject. In the laboratory experimental studies are made of the animal body and the processes and products of digestion, secretion and excretion. The course gives additional training in the chemical problems of agricultural experiment-station work, especially those connected with investigations in animal and plant nutrition. To those who will not take up scientific lines of work, but will follow practical agriculture, it will give an opportunity for a more detailed study of the chemistry and physiology of problems which were treated generally in Course 30.
3 class hours. 2 2-hour laboratory periods, credit, 5.
Professor Chamberlain and Mr. Perry.
Prerequisites, preferably Chemistry 30 or 51 and 52.

87. **III.** History of Chemistry. — Seniors. An exposition of the development of chemical knowledge from the earliest times to the present. Although the entire history will be included, the larger portion of it will receive only brief mention in order that the questions of vital interest in modern life and industry may be studied at greater length. Particular attention will be given to the questions of plant and animal industry. Chemists are strongly advised to take this course.
3 class hours. Credit, 3.
Professor Wellington.

90. **II.** Special Work in Agricultural Chemical Analysis. — Seniors. The student is given a problem to solve either in analytical chemistry or related to the agricultural industries. This is to acquaint him with the methods used in research and with the literature, and show him how to handle problems in this field of chemistry when occasion arises.

6 or 10 laboratory hours, credit, 3 or 5.
Professor Peters.

91. **III.** Special Work in Agricultural Chemical Analysis. — Seniors. As stated in Course 90.

10 laboratory hours, credit, 5.
Professor Peters.

Prerequisite, Chemistry 90.

92. **II.** Special Work in Physiological and Organic Agricultural Chemistry. — Seniors. In this course, as in Courses 90 to 94, the student will be able to give his attention primarily to one line of chemical study. To those whose tastes and interests are in connection with the organic and physiological problems of agricultural chemistry, many subjects of study present themselves, among which may be mentioned: proteins, carbohydrates, fats, organic nitrogenous compounds in fertilizers and soils and their relation to plants, the commercial production of alcohol from agricultural products, digestion and dietary studies, the chemical study of dairy products, etc.

6 or 10 laboratory hours, credit, 3 or 5.
Professor Chamberlain.

Prerequisites, Chemistry 51, 52 and 80.

93. **III.** Special Work in Physiological and Organic Agricultural Chemistry. — Seniors. As stated under Course 92.

10 laboratory hours, credit, 5.
Professor Chamberlain.

Prerequisite, Chemistry 92.

94. **II.** Special Work in Physical Chemistry. — Seniors. The field of agricultural chemistry offers many problems that have been attacked through the methods of physical chemistry; such, for example, are the hydrolysis of salts and of minerals and the absorption of salts and fertilizers by soils. Each student will select one line of work and follow it through the course, repeating some of the original work.

6 or 10 laboratory hours, credit, 3 or 5.
Professor Anderson.

Prerequisite, Chemistry 65.

95. **III.** Special Work in Physical Chemistry. — Seniors. As stated under Course 94.

10 laboratory hours, credit, 5.
Professor Anderson.

Prerequisite, Chemistry 94.

Entomology.

Professor Fernald, Professor Crampton, Associate Professor Gates, Dr. Regan.

Elective Courses.

26. **II.** 27. **III.** General and Economic Entomology. — For sophomores; juniors and seniors may elect. This is a general course in the study of insects intended for students in any line of work, and is directly continuous through two terms. It touches upon the structure of insects so far as this is needed for such a course; deals with metamorphosis, classification to the larger groups, and discusses the most important methods and materials used for control. The greater part of the time is devoted to special study of the most important insect pests, particularly of New England, showing their modes of life, the injuries they cause, and the best methods of control. In this way the most serious pests of fruit trees, ornamental trees and shrubs, market-garden and greenhouse pests, those attacking field crops and those affecting animals and man, are treated. During the winter term and in the spring term until about the first of May instruction is given by lectures and recitations; from about the first of May field work takes the place of the lectures. In this part of the course the students are shown how to find and recognize the work of the various insect pests which may be accessible at that season of the year, and they also make and preserve a collection of insects. 3 class hours. Credit, 3.

Professor Fernald.

27. **III.** General and Economic Entomology. — As stated under Course 26. **II.**
2 class hours till about May 1; thereafter 2 2-hour field periods. Credit, 2.

Professor Fernald, Professor Crampton, Dr. Regan.

50. **I.** A. Pests of Special Crops. — For juniors; seniors may elect. For students not majoring in entomology. The laboratory work is largely individual in this term. Accordingly, students majoring in subjects other than entomology, but who desire a more complete knowledge of the insects connected with their own major line of work, can obtain it here. A student majoring in floriculture, for example, will devote his laboratory time to a careful study of the insects injuring floricultural crops, learning how to recognize them and their work in their different stages, and the best methods for their control. Courses of this kind are available on the insects attacking field crops, market-garden crops, tree fruits, small fruits, shade trees and shrubs, flowers, forest trees, the domesticated animals and man. This work may be continued in the winter term also. (See 51., **II.**, A.)

50. **I.** B. Insect Morphology. — For juniors; seniors may elect. For students majoring in entomology. The lectures of this course treat of the external and internal anatomy of insects, particularly of those characters used in identification, a knowledge of which is needed in the accompanying laboratory work. In the laboratory the external anatomy of the most important groups is studied, followed by the identification of insects of these

groups, to show how the characters are made use of in learning the names of insects, and to teach the use of analytical keys.
2 class hours. 1 2-hour laboratory period, credit, 3.
Professor Crampton, Professor Fernald, Dr. Regan.
Prerequisites, Entomology 26 and 27.

51. **II.** A. Pests of Special Crops. — As stated in 50, **I.**, A.

51. **II.** B. Insect Classification. — For juniors; seniors may elect. For students majoring in entomology. Systematic identification of insects of various groups. Study of various entomological publications and methods of finding the literature on any insect.
3 2-hour laboratory periods, credit, 3.
Professor Fernald, Professor Crampton, Dr. Regan.
Prerequisite, Entomology 50, **I.**, B.

52. **III.** Economic Entomology. — For juniors; seniors may elect. Special studies on the most serious insect pests, their habits, nature of the injuries they cause and methods of control. In the lectures the composition, preparation and methods of application of the more important insecticides, their merits and defects, and studies of insecticide apparatus and other methods of control are treated. A portion of the laboratory time will be used in practical work on the topics taken up in the lectures.
1 class hour. 2 2-hour laboratory periods, credit, 3.
Professor Fernald, Professor Crampton, Dr. Regan.
Prerequisite, Entomology 51.

75. **III.** Forest and Shade-tree Insects. — For seniors; juniors may elect. A study of the insects injurious to forest and shade trees, and of methods for their control, with laboratory and field work on these insects, together with investigation of what is known about them.
1 class hour. 3 2-hour laboratory or field periods, credit, 4.
Dr. Regan.
Prerequisites, Entomology 26 and 27; 50, B, desirable.

76. **I.** Advanced Entomology. — For seniors. During this year studies of scale insects (coccidology), life histories of important pests, the preparation of bibliographies, methods of rearing, photography of insects, methods for experimental work and record keeping, and studies of the early stages of insects will be given. Insects as disease carriers, insect bionomics, and a study of the animals not insects with which entomologists are expected to deal, will also be included in this course.
2 class hours. 3 2-hour laboratory periods, credit, 5.
Professor Fernald, Professor Crampton, Dr. Regan.
Prerequisite, Entomology 52.

77. **II.** Advanced Entomology. — As stated in Course 76, **I.**
3 2-hour laboratory periods, credit, 3.
Prerequisite, Entomology 76.

78. **III.** ADVANCED ENTOMOLOGY. — As stated in Course 76, **I.**
1 class hour. 3 2-hour laboratory or field periods, credit, 4.
Prerequisite, Entomology 77.

90. **II.** EVOLUTION. — For juniors; seniors may elect. In order to demonstrate the universal scope and operation of the laws of evolution, the course includes a brief sketch of the probable origin and evolution of matter as viewed in the light of modern physical and chemical research; the evolution of the solar system, leading to the formation of the earth; the changes in the earth, preparatory to the production of life; the physical and chemical basis of life; the probable steps in the formation of living matter, and the theories concerning it; the evolution of living things; the developmental history of man, and of the races of mankind, the evolution of human intelligence, languages, culture, institutions, etc., and man's probable future in the light of his past development. Especial consideration is given to the factors of evolution, the basic principles of heredity, sex-determination, variation and similar topics, with particular reference to their application to human welfare; and the recent contributions in the field of entomology to the advancement of our knowledge of these fundamental principles are briefly reviewed. The lectures are supplemented by collateral reading, and monthly seminars will be held for the purpose of demonstration and discussion by the class.
3 class hours. Credit, 3.
Professor CRAMPTON.

Mathematics and Civil Engineering.

Professor OSTRANDER, Assistant Professor DUNCAN, Assistant Professor MACHMER, Mr. HAZELTINE.

Required Courses.

1. **I.** HIGHER ALGEBRA. — Freshmen. A brief review of radicals, quadratic equations, ratio and proportion, and progressions; graphs, binomial theorem, undetermined coefficients, summation of series, variation, continued fractions, determinants, permutations and combinations, logarithms, theory of equations. Reitz and Crathorne's "College Algebra."
5 class hours. Credit, 5.
Assistant Professor DUNCAN, Assistant Professor MACHMER and Mr. HAZELTINE.

2. **II.** HIGHER ALGEBRA. — As stated under Course 1.
2 class hours. Credit, 2.
Assistant Professor DUNCAN, Assistant Professor MACHMER and Mr. HAZELTINE.

3. **III.** SOLID GEOMETRY. — Freshmen. Theorems and exercises on the properties of straight lines and planes, dihedral and polyhedral angles, prisms, pyramids and regular solids; cylinders, cones and spheres; spherical triangles and the measurement of surfaces and solids. Wentworth and Smith's "Solid Geometry." Required unless accepted for admission.
3 class hours. Credit, 3.
Assistant Professor DUNCAN, Assistant Professor MACHMER and Mr. HAZELTINE.

5. **II.** Plane Trigonometry (in charge of Department of Physics). — Freshmen. The trigonometric functions as lines and ratios; proofs of the principal formulas, transformations; inverse functions, use of logarithms; the applications to the solution of right and oblique triangles; practical applications. Bowser's "Elements of Plane and Spherical Trigonometry."
3 class hours. Credit, 3.
Professor Hasbrouck and Assistant Professor Robbins.

6. **III.** Mensuration and Computation. — Freshmen. The course includes a review of methods of computation, with special emphasis on short and abbreviated processes, together with methods of checking computations and of forming close approximations; use of slide rule. Also the graph, mensuration of plane and solid figures, weights and measures and elementary mechanism. Numerous practical problems are selected from such subjects as the following: the mathematics of woodworking; rough lumber; general construction; forestry methods in heights of trees; pulleys, belts and speeds; power and its transmission; dairying; agronomy; computation of areas from simple measurements.
2 class hours. Credit, 2.
Assistant Professor Machmer, Assistant Professor Duncan and Mr. Hazeltine.

Elective Courses.

26. **II.** Plane Surveying. — For sophomores; juniors and seniors may elect. The elements of the subject, including the adjustment and use of the usual instruments. Textbook and lectures.
2 class hours. Credit, 2.
The Department.

27. **III.** Plane Surveying. — For sophomores; juniors and seniors may elect. As stated under Course 26. Includes field work.
3 2-hour laboratory periods, credit, 3.
The Department.
Prerequisite, Mathematics 26.

50. **I.** Analytic Geometry. — For juniors; seniors may elect. A discussion of the geometry of the line, the circle of conic sections and of the higher plane curves. Fine and Thompson's "Co-ordinate Geometry."
3 class hours. Credit, 3.
Assistant Professor Duncan.
Prerequisites, Mathematics 1, 2, 3 and 5.

51. **II.** Differential and Integral Calculus. — For juniors; seniors may elect. A first course in the subject, with some of the more important applications. Davis's "Differential and Integral Calculus."
5 class hours. Credit, 5.
Assistant Professor Duncan.
Prerequisites, Mathematics 1, 2, 3 and 5.

52. **III.** Integral Calculus. — For juniors; seniors may elect. A continuation of Course 51.
5 class hours. Credit, 5.
Assistant Professor Duncan.
Prerequisite, Mathematics 51.

53. **II.** Elementary Structures. — For juniors; seniors may elect. An elementary course in roofs and bridges. Textbook and lectures.
3 class hours. 1 2-hour laboratory period, credit, 4.
Professor Ostrander.

75. **I.** Hydraulics and Sanitary Engineering. — For seniors; juniors may elect. Hydrostatics, theoretical hydraulics, orifices, weirs, pipes, conduits, water supply, hydraulic motors, sewers and sewage treatment. Textbook and lectures.
5 class hours. Credit, 5.
Professor Ostrander.

76. **I.** Materials of Construction, Foundations and Masonry Construction. — For seniors; juniors may elect. Textbook and lectures.
4 class hours. 1 2-hour laboratory period, credit, 5.
Professor Ostrander.

77. **II.** Roads and Railroads. — For seniors; juniors may elect. Topographic and higher surveying, highway construction, earthwork, pavements and railroad construction. Textbook and lectures.
3 class hours. Credit, 3.
Professor Ostrander.

78. **III.** Roads and Railroads. — For seniors; juniors may elect. As stated under Course 77.
3 2-hour laboratory periods, credit, 3.
Professor Ostrander.
Prerequisite, Mathematics 77.

79. **I.** Applied Mechanics. — Seniors. A course in applied mechanics, based on the calculus, with problems. Textbooks and lectures.
5 class hours. Credit, 5.
Professor Ostrander.
Prerequisite, Mathematics 51.

Microbiology.

Professor Marshall, Associate Professor vanSuchtelen, Dr. Itano, Mr. Ray.

[Courses 50 and 51 are especially adapted to those who wish a general comprehensive, although elementary, survey of agricultural microbiology.]

Elective Courses.

50. **I. and III.** Introduction and General Microbiology. — For juniors; seniors may elect. A review of the field of microbiology as a whole, with special reference to hygienic microbiology, will constitute this course. It

will be taught by means of lectures, demonstrations and textbooks. Although desirable, it will not be required as a prerequisite to all courses that follow, and may be taken along with Course 51.

5 class hours. Credit, 5.

Professor MARSHALL.

51. **I., II. and III.** MORPHOLOGICAL, CULTURAL AND PHYSIOLOGICAL MICROBIOLOGY. — For juniors; seniors may elect. Types of micro-organisms, technic of handling, methods of culture and functions of micro-organisms are considered. This course is elementary and fundamental to all applied and special microbiological studies, and therefore is made a prerequisite to all courses following. One hour will be scheduled.

10 laboratory hours, credit, 5.

Dr. ITANO and Mr. RAY.

52. **III.** ADVANCED MORPHOLOGICAL, CULTURAL AND PHYSIOLOGICAL MICROBIOLOGY. — For juniors; seniors may elect. The purpose of this course is to prepare the student for a more intimate knowledge of microbiological agricultural problems. To accomplish this object it is necessary to provide more advanced technic and methods of culture, together with a more extensive knowledge of micro-organisms and their functions. One hour will be scheduled.

10 laboratory hours, credit, 5.

Dr. ITANO and Mr. RAY.

Prerequisite, Microbiology 51.

75. **II.** AGRICULTURAL MICROBIOLOGY. — For seniors; juniors may elect. This general comprehensive course is designed to cover in an elementary manner those subjects only which confront the student of general agriculture, — the microbiological features of air, water, sewage, soil, dairy, fermentations, food, vaccines, antisera, microbial plant infections, methods and channels of infections, immunity and susceptibility, microbial infections of man and animals, methods of control or sanitary and hygienic practices. One hour will be scheduled.

10 laboratory hours, credit, 5.

Professor MARSHALL, Associate Professor VANSUCHTELEN, or Dr. ITANO and Mr. RAY.

Prerequisite, Microbiology 51.

76. **III.** AGRICULTURAL MICROBIOLOGY. — For seniors; juniors may elect. As stated under Course 75. One hour will be scheuled.

10 laboratory hours, credit, 5.

Professor MARSHALL, Associate Professor VANSUCHTELEN, or Dr. ITANO and Mr. RAY.

Prerequisites, Microbiology 52 and 75.

80. **II.** SOIL MICROBIOLOGY. — For seniors; juniors may elect. Such subjects as the number and development of micro-organisms in different soils; the factors which influence their growth, food, reaction, temperature, moisture and aeration; the changes wrought upon inorganic and organic matter in the

production of soil fertility, ammonification, nitrification and denitrification; fixation of nitrogen symbiotically and non-symbiotically; methods of soil inoculation receive attention. One hour will be scheduled.

10 laboratory hours, credit, 5.
Associate Professor vanSuchtelen.

Prerequisite, Microbiology 51.

81. I. Hygienic Microbiology. — For seniors; juniors may elect. An attempt will be made to select for this course certain material which should be the possession of every individual, and which is basic to public hygiene and sanitation, as applied to man and animals. The microbiology of water supplies, food supplies, vaccines, antisera or antitoxins; the channels by which micro-organisms enter the body, the influence of body fluids and tissues upon them, body reactions with micro-organisms (susceptibility and immunity); the micro-organisms of some of the most important infectious diseases, methods of control, including disinfectants and disinfection, antiseptics, antisepsis and asepsis, will be treated. One hour will be scheduled.

10 laboratory hours, credit, 5.
Professor Marshall and — —, or Dr. Itano and Mr. Ray.

Prerequisites, Microbiology 50 and 51.

82. I. Dairy Microbiology. — For seniors; juniors may elect. Special emphasis will be placed upon milk supplies. The microbial content of milk, its source, its significance, its control; microbial taints and changes in milk; groups or types of organisms found in milk; milk as a carrier of disease-producing organisms; the value of straining, aeration, centrifugal separation, temperature, pasteurization; the abnormal fermentations of milk; bacteriological milk standards and their interpretation; ripening of milk and cream; the bacterial content of butter; a passing survey of the microbiology of cheeses; a study of special dairy products, as ice cream, condensed milk, artificial milk drinks (the products of microbial actions), represents a list of topics considered.

10 laboratory hours, credit, 5.
Professor Marshall and Mr. ——.

Prerequisites, Microbiology 51, Dairying 51.

83. I. Food Microbiology. — For seniors; juniors may elect. A study of food preservation by means of drying, canning, refrigerating and addition of chemicals will be pursued. Food fermentations, as illustrated by bread, pickles, sauerkraut, ensilage, vinegar, wine, etc., will be examined. Decomposition of foods, as may be seen in meat, oysters, fish, milk, etc., as well as diseased foods, will receive consideration. Contamination of food supplies by means of water, handling, exposure, diseased persons, etc., is of especial significance, and will be demonstrated by laboratory exercises. One hour will be scheduled.

10 laboratory hours, credit, 5.
Professor Marshall and Mr. ——.

Prerequisite, Microbiology 51.

Physics.

Professor Hasbrouck, Assistant Professor Robbins, Mr. Thompson.

[The fundamental and basic importance of the laws and phenomena of physics makes necessary no explanation of the introduction of this subject into the curriculum of an agricultural college. The logical development of the subject emphasizes the importance of physics as a science in itself. Special emphasis is laid, however, on the correlation of the principles studied with the sciences of agriculture, botany, chemistry, zoölogy, thus furnishing an extra tool by use of which the student's work in all the subjects may be more effective.]

Required Courses.

25. **I.** General Physics. — Sophomores. Mechanics of solids and fluids. This course includes statics, with equilibrium of rigid bodies, work, energy and friction; kinetics, considering rectilinear motion and motion in a curved path; harmonic motion; rotation of rigid bodies, including kinematics of rotation; liquids and gases, with properties of fluids at rest and in motion; properties of matter and its internal forces, including elasticity, capillarity, surface tension.
3 class hours. 1 2-hour laboratory period, credit, 4.
Professor Hasbrouck, Assistant Professor Robbins, Mr. Thompson.

26. **II.** Electricity and Magnetism. — Sophomores. The work in electricity includes such subject-matter as magnetism, electrostatics, electric currents with their production, chemical, heating and mechanical effects; battery cells, measurement of voltage, current flow and resistance, motors and generators.
2 class hours. 1 2-hour laboratory period, credit, 3.
Assistant Professor Robbins and Mr. Thompson.

Elective Courses.

27. **III.** Heat and Light. — For sophomores; juniors and seniors may elect. Thermometry, expansion, colorimetry and specific heat, transmission of heat, changes of state, radiation and absorption. Wave theory of light, optical instruments, analysis of light, color, interference, diffraction, polarization.
4 class hours. 1 2-hour laboratory period, credit, 5.
Professor Hasbrouck, Assistant Professor Robbins and Mr. Thompson.

50. **I.** Electricity, Heat and Light. — For juniors; seniors may elect.
1 class hour. 2 2-hour laboratory periods, credit, 3.
Assistant Professor Robbins.

Prerequisite, Physics 27.

51. **II.** Electricity, Heat and Light. — For juniors; seniors may elect. Continuation of Course 50.
1 class hour. 2 2-hour laboratory periods, credit, 3.
Assistant Professor Robbins.

Prerequisite, Physics 50.

52. **III.** Electricity, Heat and Light. — For juniors; seniors may elect. Continuation of Courses 50 and 51.
1 class hour. 2 2-hour laboratory periods, credit, 3.
Assistant Professor Robbins.

Prerequisite, Physics 51.

Veterinary Science.

Professor Paige, Associate Professor Gage.

[The courses in veterinary science have been arranged to meet the needs of students who propose following practical agriculture, and of prospective students of human and comparative medicine.]

Elective Courses.

50. **I.** Veterinary Hygiene and Stable Sanitation. — For juniors; seniors may elect. This course is intended to familiarize the student with the relation of water, food, air, light, ventilation, care of stables, disposal of excrement, individual hygiene, etc., to the prevention of disease in farm animals.
5 class hours. Credit, 5.
Professor Paige.

51. **II.** General Veterinary Pathology, Materia Medica and Therapeutics. — For juniors; seniors may elect. In this course such fundamental and general pathological conditions are studied as inflammation, fever, hypertrophy, atrophy, etc., a knowledge of which is essential in the diagnosis, prevention and treatment of disease. The course in pathology is followed by one in materia medica and therapeutics, dealing with the origin, preparation, pharmacology, pharmacy, administration and therapeutic use of the more common drugs. Poisonous plants and symptoms and treatment of plant poisoning are also considered.
5 class hours. Credit, 5.
Professor Paige.

75. **I.** Comparative (Veterinary) Anatomy. — For seniors; juniors may elect. The anatomy of the horse is studied in detail, and that of other farm animals compared with it where differences exist. This course is essential for those students wishing to elect Course 76.
5 class hours. Credit, 5.
Professor Paige.

76. **II.** Theory and Practice of Veterinary Medicine; General, Special and Operative Surgery. — For seniors; juniors may elect. A course intended to familiarize the student with the various medical and surgical diseases of the different species of farm animals. Particular attention is given to diagnosis and first-aid treatment. The student is taught the technic of simple surgical operations that can with safety be performed by the stock owner. Lectures, demonstrations and practice. This course should be taken in conjunction with Course 51.
5 class hours. Credit, 5.
Professor Paige.

Prerequisite, Veterinary 75.

78. **I.** Essentials of General Pathology. — For seniors; juniors may elect. This course is planned to introduce the student to some of the essential anatomical, histological and general physiological phenomena essential to the understanding of some of the simple general pathological conditions found in domestic animals. Some of the common methods of diagnosis will be considered in the laboratory. The various chemical and biological reactions and tests will be presented from the standpoint of pure science, showing applications of chemistry and biology. The course will serve to liberally educate and stimulate in the student of agriculture the appreciation of some of the methods used in animal pathology for detecting and controlling some of the more common animal diseases. Lectures, demonstration and laboratory work.

2 3-hour laboratory periods, credit, 3.
Associate Professor Gage.

79. **II.** Essentials of General Animal Pathology. — For seniors; juniors may elect. This is a continuation of Course 78, and is devoted to a study of some of the common pathological conditions by means of prepared sections, the aim being to demonstrate to the student abnormal animal histological structures commonly observed when material from various cases of animal diseases is prepared for microscopical study. Some of the biological products used in protecting animals against disease will be considered.

2 3-hour laboratory periods, credit, 3.
Associate Professor Gage.

Prerequisite, Veterinary 78.

80. **III.** Essentials of General Animal Pathology. — For seniors; juniors may elect. As stated in Courses 78 and 79.

2 3-hour laboratory periods, credit, 3.
Associate Professor Gage.

Prerequisite, Veterinary 79.

85. **I.** Avian Pathology. — For seniors; juniors may elect. A course in poultry diseases. The object of this course is to present information concerning the common diseases of poultry, their etiology, diagnosis and prevention. The work will consist of a systematic study of the diseases of the alimentary tract, liver and abdominal region, followed by a study of the diseases of the respiratory system, circulation and kidneys. The important disease-producing external and internal parasites will be considered; also diseases of the skin and reproductive organs. Lectures and demonstrations.

2 3-hour laboratory periods, credit, 3.
Associate Professor Gage.

86. **II.** Avian Pathology. — For seniors; juniors may elect. As stated under Course 85, also devoted to the study of some of the special diseases of poultry. Recent methods used in the control of these diseases will be considered and opportunity offered the student for demonstrating various disease processes by means of prepared slides. Lectures, demonstrations and laboratory work.

2 3-hour laboratory periods, credit, 3.
Associate Professor Gage.

Prerequisite, Veterinary 85.

87. **III.** Avian Pathology. — For seniors; juniors may elect. As stated under Courses 85 and 86.

2 3-hour laboratory periods, credit, 3.
Associate Professor Gage.

Prerequisite, Veterinary 86.

Zoölogy and Geology.

Associate Professor Gordon, Dr. Ball.

Zoölogy.

Required Courses.

25. **I.** General Zoloögy. — Sophomores. This course gives an outline of the underlying principles of zoölogy and an introduction to animal structure.

1 class hour. 2 2-hour laboratory periods, credit, 3.
Associate Professor Gordon and Dr. Ball.

Elective Courses.

27. **III.** Elements of Mammalian Anatomy. — For sophomores; juniors and seniors may elect. This course is offered as a preparation for work in histology, embryology, general vertebrate zoölogy, etc. It also deals briefly with the essentials of physiology. The course is open to prospective students in physiological chemistry, microbiology, animal husbandry, veterinary sciences, etc.

1 class hour. 2 2-hour laboratory periods, credit, 3.
Associate Professor Gordon and Dr. Ball.

Prerequisite, Zoölogy 25.

50. **I.** Synoptic Invertebrate Zoölogy. — For juniors; seniors may elect. This course gives a synopsis of the distinguishing characters of the different phyla and classes of invertebrates.

1 class hour. 2 2-hour laboratory periods, credit, 3.
Associate Professor Gordon and Dr. Ball.

Prerequisite, Zoölogy 25.

51. **II.** Synoptic Invertebrate Zoölogy. — For juniors; seniors may elect. .Continuation of Course 50.

1 class hour. 2 2-hour laboratory periods, credit, 3.
Associate Professor Gordon and Dr. Ball.

Prerequisite, Zoölogy 50.

52. **III.** Synoptic Invertebrate Zoölogy. — For juniors; seniors may elect. Continuation of Courses 50 and 51.

1 class hour. 2 2-hour laboratory periods, credit, 3.
Associate Professor Gordon and Dr. Ball.

Prerequisite, Zoölogy 51.

53. **I.** Elements of Microscopic Technique. — For juniors; seniors may elect. This course gives methods of preparing material for microscopic examination.

3 2-hour laboratory periods, credit, 3.
The Department.

Prerequisite, Zoölogy 25.

54. **II.** Elements of Histology. — For juniors; seniors may elect. This course involves preparation and study of normal animal tissues.

3 2-hour laboratory periods, credit, 3.
The Department.

Prerequisites, Zoölogy 27 and 53.

55. **III.** Elements of Histology. — For juniors; seniors may elect. Continuation of Course 54.

3 2-hour laboratory periods, credit, 3.
The Department.

Prerequisite, Zoölogy 54.

75. **I.** Special Zoölogy.[1] — Juniors, seniors, graduates, vocational students and others may ask, and in most cases may arrange, for special work in zoölogy. Such work as is desired in connection with an undergraduate major in another department, or in connection with a vocational course, should be formulated in consultation with officers having the major or vocational course in charge before the request for the work is made. For juniors, seniors and graduates who desire to extend their knowledge of zoölogy along more advanced or special lines, and who are adequately prepared, provision will gladly be made when possible. Work taken under this title may extend through the year, or may be for one term only.

1 class hour. 2 2-hour laboratory periods; hours by arrangement, credit, 3.
The Department.

Prerequisites, each case will be decided by itself.

76. **II.** Special Zoölogy. — As stated under Course 75.

1 class hour. 2 2-hour laboratory periods, credit, 3.
The Department.

Prerequisites, each case will be decided by itself.

77. **III.** Special Zoölogy. — As stated under Course 75.

1 class hour. 2 2-hour laboratory periods, credit, 3.
The Department.

Prerequisites, each case will be decided by itself.

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[1] Those who desire work in zoölogy as a minor for the degree of master of science or for the degree of doctor of philosophy may elect certain courses offered to juniors or seniors, or may arrange for separate work. The graduate student who elects undergraduate courses must meet the requirements of the graduate standards of work and accomplishment.

Geology.

Required Courses.

2. **II.** Agricultural Geology. — Freshmen. The elements of geology in their application to agriculture.
2 class hours. Credit, 2.
Associate Professor Gordon.

Elective Courses.

27. **III.** General Geology. — For sophomores; juniors and seniors may elect. Rock-forming minerals; rock types; rock weathering; dynamical, structural and surface geology. Lectures, map and field work.
3 class hours. 2 2-hour laboratory periods, credit, 5.
Associate Professor Gordon.

DIVISION OF THE HUMANITIES.

Professor Sprague.

Economics and Sociology.

Professor Sprague.

[The courses in economics and sociology are planned with the purpose of giving the student that knowledge and understanding of the important factors and problems in this field of study and life which every active citizen and educated man ought to have.]

[Heavy-faced type indicates the term in which the course is given. Numbering of courses: 1 to 24, inclusive, freshmen; 25 to 49, inclusive, sophomores; 50 to 74, inclusive, juniors; 75 to 99, inclusive, seniors.]

Elective Courses.

26. **II.** Civilizations, Ancient and Modern. — For sophomores; others may elect. This course studies the evolutionary origin and history of man; characteristics of primitive man, departure from the animal status and beginnings of civilization; origin and development of industries, arts and sciences; the evolution of languages, warfare, migrations and social institutions; a study of the powerful natural and human forces that have brought man from the early stages to modern development; characteristic features of the leading civilizations and races of ancient and modern times; beneficial and dangerous factors in American life in view of the history of human civilization.
5 class hours. Credit, 5.
Professor Sprague.

50. **I.** Business and Industry. — For juniors and seniors. The forms, organization, administration and labor problems of business. This course is devoted to the following subjects: methods of organizing, financing and administering corporations and partnerships; forms of business administration, wholesaling, jobbing, retailing, advertising, credits and collections; systems of industrial remuneration for wage earners, co-operation and preserving industrial peace; problems concerned with protective legislation for workmen and employers, sweated industries, prison labor, child labor and industrial education.
5 class hours. Credit, 5.
Professor Sprague.

51. **II.** Introduction to Economic Principles and Problems. — For juniors. This course is devoted to the study of the following subjects: definitions of economic terms, such as wealth, capital, value, etc.; factors of production, exchange and consumption; principles of economic production, supply and demand, diminishing returns, division of labor, productive organization, concentration of capital and labor, trust and monopoly problems, public control of production and distribution; principles of exchange, theories of value, money and its problems; international trade, tariff and free trade theories, American merchant marine, reciprocity, and trade treaties; forms of income, wages, interest, rent, profits and the forces which govern them; principles of spending, economy, luxury, conservation of individual and national resources; principles and agencies for saving, investments, banks, building associations,

insurance of all kinds; schemes for social organization; socialism, communism, industrial democracy. Textbook and readings.
5 class hours. Credit, 5.
Professor Sprague.

75. I. Social Institutions and Social Reforms. — For seniors; juniors by permission. This course is devoted to the study of the social institutions, such as the family, the State, property, religions; and to such current problems as eugenics, race suicide, divorce, crime and delinquent classes, prison reform, prevention and treatment of dependents and defectives, poverty, its causes and preventions; constructive modern social reform movements for insurance of wage earners, protection of childhood, assurance of safety, health and play time for all classes. The correctional and charitable institutions of Massachusetts will be studied in considerable detail.
5 class hours. Credit, 5.
Professor Sprague.

77. III. Public Finance, Taxation, Money and Banking. — For seniors. This course studies systems and problems of taxation as they are found in Europe and America; objects for spending public revenue; public debts and methods of organizing them; systems of money and currency problems of America; types, methods and functions of banks; economic and financial crises and depressions in the United States; modern war finance. Readings and lectures.
5 class hours. Credit, 5.
Professor Sprague.

History and Government.

Elective Courses.

50. III. Government. — For juniors; seniors may elect. This course will cover subjects as follows: forms and working methods of the governments of Great Britain, Germany, France, Russia, Switzerland, New Zealand and Canada; historic types and theories of government; forms and methods of Federal, State and local governments in America; progress and problems of democracy and new reform movements in organization and administration; new tendencies towards social legislation and extension of governmental control over broader interests of the people.
5 class hours. Credit, 5.
Professor Sprague.

75. II. History of New England. — For seniors; juniors may elect. Treating New England as a geographical and political unit, this course aims to give a survey of its religious, social, economic and political history. The development of its institutions, the growth of its industries, the spread of its population to other sections of the country, its influence upon national character and politics are phases of the subject which will be discussed. Assigned readings and theses will be required.
3 class hours. Credits, 3.
Miss Jefferson.

Languages and Literature.

Professor LEWIS, Associate Professor NEAL, Associate Professor ASHLEY, Associate Professor MACKIMMIE, Assistant Professor PRINCE, Assistant Professor PATTERSON, Miss GOESSMANN, Mr. HARMOUNT, Mr. JULIAN, Mr. RAND, Mr. PAYNE.

ENGLISH.

Required Courses.

1. **I.** 2. **II.** 3. **III.** ENGLISH. — Freshmen. Composition. Intended to teach straight thinking, sound structure, clear and correct expression. Lectures, recitations, theme writing and conferences. Textbooks: Canby and others, "English Composition in Theory and Practice;" Woolley's "Handbook of Composition."

3 class hours each term. Credit, 3 each term.

Assistant Professor PRINCE, Assistant Professor PATTERSON, Mr. RAND and Mr. PAYNE.

25. **I.** 26. **II.** 27. **III.** ENGLISH. — Sophomores. A general reading course in English literature. Two class hours each term. Credit, 2 each term.

Professor LEWIS and Miss GOESSMANN.

Elective Courses in English Language and Literature.

[The elective courses in English fall into two groups. Both groups are intended to increase the student's appreciation of literature as a means to enjoyment, education and spiritual growth. Group one (Courses 50, 51, 52, 53, 54 and 55) will, besides introducing the student to individual writers, emphasize the life and thought of the times, political, economic and social, in order that the student may realize literature as the expression of individual genius representing (by leading it or summarizing it) the thought and spirit of a period or a social unit. Group two (Courses 75, 77, 79 and 80) will tend more to emphasize form-characteristics, artistic quality or historical development of literary types, or individual great writers. Courses 50, 51, 55, 75, 79 and 80 are offered in 1916-17; Courses 52, 53, 54, 55, 77 and 80 are offered in 1915-16 and 1917-18.]

50. **I.** ENGLISH WRITERS AND THOUGHT. — *Verse from* 1744 *to* 1832 (1916, 1918). — Alternates with Course 53 for juniors; seniors may elect. A course in history, appreciation and understanding. Some of the writers studied are Gray, Goldsmith, Burns, Coleridge, Wordsworth, Keats, Shelley, Scott and Byron.

3 class hours. Credit, 3.

51. **II.** ENGLISH WRITERS AND THOUGHT. — Alternates with Course 54. *Nineteenth Century Verse* (1915, 1917). — Juniors; seniors may elect. In general conception this course is like Course 50. Tennyson, Browning, Mrs. Browning, Arnold, the Rossettis and Morris, Swinburne and Clough are the authors to be studied.

3 class hours. Credit, 3.

Professor LEWIS.

57. **III.** ENGLISH WRITERS AND THOUGHT. — For juniors; seniors may elect. As stated under Course 51.

2 class hours. Credit, 2.

Professor LEWIS.

Prerequisite, English 51.

52. **III.** English Writers and Thought. — *From Milton to Pope* (1915–17). — For juniors; seniors may elect. A survey course that will emphasize the leading writers of the periods, including Bacon, Milton, Dryden, Addison and the essayists, Swift and Pope. Given every second year.
3 class hours. Credit, 3.

53. **I.** English Writers and Thought. — Alternating with Course 50. *Prose from* 1744 *to* 1832 (1915, 1917). — For juniors; seniors may elect. A course in English prose paralleling Course 51. Some of the writers studied are Johnson, Sterne, Goldsmith, Burke, Miss Burney, Coleridge, Landor, Lamb, DeQuincey and Hazlitt.
3 class hours. Credit, 3.

54. **III.** English Writers and Thought. — Alternating with Course 51. *Nineteenth Century Prose* (1916, 1918). — For juniors; seniors may elect. This course parallels Course 51. Among the writers discussed will be Macaulay, Carlyle, Ruskin, Newman and Arnold.
3 class hours. Credit, 3.
Professor Lewis.

58. **III.** English Writers and Thought. — For juniors; seniors may elect. As stated under Course 54.
2 class hours. Credit, 2.
Professor Lewis.

Prerequisite, English 54.

55. **II.** American Writers and Thought. — For juniors; seniors may elect. Intended to give a general survey of literature in America, especially in the nineteenth century, with an introduction to the work of the best known writers, and with especial attention to the relations between national life and history and national thought as expressed in literature. The usual authors — Irving, Cooper, Bryant, Poe, Longfellow, Emerson, Hawthorne, Whittier, Parkman, Lowell, Holmes, Whitman, Lanier — will be discussed, and attention will be given to southern and western authors. Present writers and tendencies will also receive some notice.
3 class hours. Credit, 3.
Assistant Professor Prince.

56. **III.** American Writers and Thought. — For juniors; seniors may elect. As stated under Course 55.
2 class hours. Credit, 2.
Assistant Professor Prince.

Prerequisite, English 55.

60. **I.** The Literature of Rural Life. — For juniors; seniors may elect. A critical and appreciative study of writers, both in prose and poetry, who have interpreted nature from the viewpoint of the lover of country life, and those who have idealized agriculture, horticulture and other rural pur-

suits, together with those who have upheld as an ideal the development of a rural environment in cities.

3 class hours. Credit, 3.

Miss Goessmann.

61. **II.** The Literature of Rural Life. — For juniors; seniors may elect. As stated under Course 60.

2 class hours. Credit, 2.

Miss Goessmann.

Prerequisite, English 60.

75. **III.** Prose Fiction. — Alternating with Course 77. *The Novel* (1916, 1918). — For seniors; juniors may elect. Readings, references, reports and classroom talks. The course is mainly informal. [Withheld 1916.]

1 class hour. 2 2-hour laboratory periods, credit, 3.

Associate Professor Neal.

77. **III.** Prose Fiction. — Alternating with Course 75. *The Short Story* (1915, 1917). — For seniors; juniors may elect. Readings, references, reports and classroom talks. The course is mainly informal. General texts, Neal's "Short Stories in the Making" and "To-day's Short Stories Analyzed."

1 class hour. 2 2-hour laboratory periods, credit, 3.

Associate Professor Neal.

79. **II.** The Drama. — For seniors; juniors may elect. A cursory survey of early English drama, its origin, forms and meaning, will be followed by a careful study of Shakespeare. Four of his plays will be analyzed in detail, and many others will be read and discussed.

3 class hours. Credit, 3.

Mr. Rand.

80. **III.** The Drama. — For seniors; juniors may elect. The course will trace the development of modern drama, especial attention being given to plays by Congreve, Goldsmith, Sheridan, Robertson, Jones, Pinero, Fitch, Shaw, Moody and Ibsen.

2 class hours. Credit, 2.

Mr. Rand.

Prerequisite, English 79.

Rural Journalism.

[The courses in journalism emphasize rural journalism. They aim to acquaint the student with the elementary problems and theory of journalism as a profession or vocation, and to exercise him, as far as conditions permit, in the commoner aspects of journalistic work, such as news-gathering, news-writing, desk-editing and editorial writing. By rural journalism is meant the application of journalistic principles in getting and suitably presenting material adapted to the nonurban rather than to the urban or metropolitan reader, so far as their interests are distinct. This includes agricultural journalism, but is by no means confined to that. As practical work, members of the classes supply "The Bay State Ruralist," a feature page for the "Springfield Union," and the "New Bedford Standard." Cordial unofficial relations are maintained with the college paper, "The Massachusetts Collegian."]

Elective Courses.

50. **I.** Foundations of Writing: Exposition. — For juniors; seniors may elect. Advanced composition; planning expository thought; expository structure; specimens, including contemporary articles from farm and rural

life publications; some bulletin writing, including presentation of technical information for nontechnical readers.
3 class hours. Credit, 3.
Associate Professor Neal.

51. II. Foundations of Writing: Narration and Description. — For juniors; seniors may elect. The fundamental elements of style, word-choice, diction, sentence form and paragraph types. Description of persons, places, objects, industries and productional processes, the temper and characteristic aspects of public gatherings, moods, behavior and character-sketching. Narration of incident, sustained action, events in series and the like, as in biography, dramatic situation, history and fiction.
3 class hours. Credit, 3.
Associate Professor Neal, Mr. Rand.

52. III. Foundations of Writing: Magazine Writing. — For seniors; juniors may elect. Study and writing of various forms of magazine and similar articles.
3 class hours or equivalent in laboratory. Credit, 3.
Associate Professor Neal.
Prerequisite, one or more junior courses in journalism, or experience on college publications.

53. I. News-gathering and News-writing. — For juniors; seniors may elect. The foundation aims and conceptions of journalism. Readings, lectures, quizzes and personal conferences; reporting on runs and on assignment; regular reading of a daily paper and of a weekly review or farm journal, with reports. Central purpose, to develop ability to pick out essentials from inessentials, perceive elements of interest, and present facts with appeal to the reader. This course and Courses 54 and 55 are suited to non-majoring students whose vocation will require the popular presentation of technical or other information; *e.g.*, extension workers, county agents, agricultural school instructors, experiment-station editors, survey and other social service workers, men engaged in sociological or economic investigations, landscape architects and civil and sanitary engineers.
6 laboratory hours, credit, 3.
Associate Professor Neal.

54. II. News-gathering and News-writing. — For juniors; seniors may elect. As outlined under Course 53, except that students who have taken Course 53 will be assigned different readings, and may be given a larger amount of reporting or other writing.
6 laboratory hours, credit, 3.
Associate Professor Neal.

55. III. News-gathering and News-writing. — For juniors; seniors may elect. As stated under Courses 53 and 54.
6 laboratory hours, credit, 3.
Associate Professor Neal.

77. **I.** Editorial, Materials and Methods. — For seniors; juniors may elect. Readings, quizzes, reports and personal conferences; regular reading of one daily paper and one weekly review or rural life periodical; writing of editorial articles; current events or history. Recommended to nonmajoring students who desire practice in discovering the significant aspects of matters of public attention and in effectively expressing comment thereon.
6 laboratory hours, credit, 3.
Associate Professor Neal.

78. **II.** Editorial Materials and Methods. — For seniors; juniors may elect. As stated under Course 77.
6 laboratory hours, credit, 3.
Associate Professor Neal.

79. **III.** Editorial Materials and Methods. — For seniors; juniors may elect. As stated under Course 77.
6 laboratory hours, credit, 3.
Associate Professor Neal.

80. **I.** Advanced Journalistic Practice. — Seniors. Preparation, editing and publication of a rural life page or periodical.
8 or 10 laboratory hours, credits, 4 or 5.
Associate Professor Neal.

81. **II.** Advanced Journalistic Practice. — Seniors. As stated under Course 80.
8 or 10 laboratory hours, credits, 4 or 5.
Associate Professor Neal.

82. **III.** Advanced Journalistic Practice. — Seniors. As stated under Course 80.
8 or 10 laboratory hours, credits, 4 or 5.
Associate Professor Neal.

Public Speaking.

Required Courses.

1. **I.** 2. **II.** 3. **III.** Public Speaking. — Freshmen. Freshmen public speaking is required in the first, second or third term, at the option of the instructor. The course is concerned with the actual problems which confront the man who would speak convincingly and persuasively. Much attention, therefore, is given to the preparation and delivery of extempore speeches. Textbook, Robinson's "Effective Public Speaking," supplemented by class work and discussions. First, second or third terms, as directed.
1 class hour. Credit, 1.
Assistant Professor Prince, Assistant Professor Patterson, Mr. Rand.

Elective Courses.

50. **I.** Argumentation. — For juniors; seniors may elect. The course aims to present the fundamental principles of argumentation as applied to oral and written discourse, and intends to develop in the student power to

handle argument convincingly and persuasively. Lectures, discussions of leading questions of the day, practice in brief-drawing and the writing of forensics. Textbook, Foster's "Argumentation and Debating." The course is recommended for those who desire to enter the intercollegiate debates.

3 class hours. Credit, 3.

Assistant Professor PRINCE.

Prerequisite, Public Speaking 1, 2 or 3.

51. **II.** OCCASIONAL ORATORY. — For juniors; seniors may elect. The course involves a study of the elements of vocal expression and action; speeches on assigned subjects; prescribed reading; the preparation and delivery of several formal orations. Textbook, Shurter's "The Rhetoric of Oratory." The course is recommended for those who wish to enter the Flint contest.

3 class hours. Credit, 3.

Assistant Professor PRINCE.

Prerequisite, Public Speaking 1, 2 or 3.

French and Spanish.

Associate Professor MACKIMMIE, Mr. HARMOUNT.

FRENCH.

Required Courses.

1. **I.** 2. **II.** 3. **III.** ELEMENTARY FRENCH. — Freshmen; open upon arrangement to other students. The essentials of grammar are rapidly taught and will be accompanied by as much reading as possible. This course is required of freshmen presenting German for entrance who do not continue that language and have not studied French.

3 class hours each term. Credit, 3 each term.

Mr. HARMOUNT.

4. **I.** 5. **II.** 6. **III.** INTERMEDIATE FRENCH. — Freshmen; open upon arrangement to other students. Training for rapid reading. The reading of a number of short stories, novels and plays; composition, reports on collateral reading from periodicals and scientific texts in the library.

3 class hours each term. Credit, 3 each term.

Associate Professor MACKIMMIE, Mr. HARMOUNT.

Prerequisite, required of freshmen who present two years of French for entrance and do not take German.

Elective Courses.

25. **I.** INTERMEDIATE FRENCH. — For sophomores; open upon arrangement to other students. Training for rapid reading; the reading of a number of short stories, novels and plays; readings from periodicals and scientific texts in the library.

3 class hours. Credit, 3.

Associate Professor MACKIMMIE.

Prerequisites, French 1, 2 and 3.

26. **II.** Intermediate French. — For sophomores; open upon arrangement to other students. As stated under Course 25.
3 class hours. Credit, 3.
Associate Professor Mackimmie.
Prerequisite, French 25.

27. **III.** Intermediate French. — For sophomores; open upon arrangement to other students. As stated under Course 25.
3 class hours. Credit, 3.
Associate Professor Mackimmie.
Prerequisite, French 26.

28. **I.** Advanced French. — For sophomores; open upon arrangement to other students. A reading course. Balzac's "Eugénie Grandet" and "Le Père Goriot," and other masterpieces of the nineteenth century; Brunetière's "Honoré de Balzac" and Harper's "Masters of French Literature;" readings in the library and written reports.
3 class hours. Credit, 3.
Mr. Harmount.
Prerequisites, French 4, 5 and 6.

29. **II.** Advanced French. — For sophomores; open upon arrangement to other students. As stated under Course 28.
3 class hours. Credit, 3.
Mr. Harmount.
Prerequisites, French 4, 5 and 6.

30. **III.** Advanced French. — For sophomores; open upon arrangement to other students. General view of the history of French literature; Kastner and Atkins' "History of French Literature." Representative works of the important periods will be studied in class. Outside reading will be required.
3 class hours. Credit, 3.
Mr. Harmount.
Prerequisites, French 25 and 26, or French 28 and 29.

50. **I.** Scientific French. — For juniors; seniors may elect. This course is planned to meet the requirements of the individual student, and aims to equip him with exact English equivalents for the French scientific terms in his particular science. Word lists of scientific terms will be required, and also weekly readings and reports from scientific works in the subject in which he is majoring. Several scientific readers will be read.
3 class hours. Credit, 3.
Mr. Harmount.
Prerequisites, French 4, 5 and 6, or French 25, 26 and 27.

51. **II.** Scientific French. — For juniors; seniors may elect. As stated under Course 50.
3 class hours. Credit, 3.
Mr. Harmount.
Prerequisites, French 4, 5 and 6, or French 25, 26 and 27.

52. **III.** Scientific French. — For juniors; seniors may elect. As stated under Course 50.
3 class hours. Credit, 3.
Mr. Harmount.
Prerequisites, French 4, 5 and 6, or French 25, 26 and 27.

75. **I.** French Literature. — For seniors; juniors may elect. The object of Courses 75, 76 and 77 is to give an introduction to recent movements in French literature. Course 75 will deal with the drama, and plays by Augier, A. Dumas, fils, Delavigne and some contemporary dramatists will be read and studied.
3 class hours. Credit, 3.
Associate Professor Mackimmie.
Prerequisites, French 4, 5 and 6, or French 25, 26 and 27.

76. **II.** French Literature. — For seniors; juniors may elect. This course deals with the novel. Works by Flaubert, the De Goncourts and Zola will be read. Written reports are required on outside reading.
3 class hours. Credit, 3.
Associate Professor Mackimmie.
Prerequisites, French 4, 5 and 6, or French 25, 26 and 27.

77. **III.** French Literature. — For seniors; juniors may elect. Modern criticism. Sainte-Beuve, "Causeries de Lundi" (Harper) and works by Taine and Renan. Reference book, Lanson's "Histoire de la Litterature Française."
3 class hours. Credit, 3.
Associate Professor Mackimmie.
Prerequisites, French 4, 5 and 6, or French 25, 26 and 27.

Spanish.

Elective Courses.

50. **I.** Elementary Spanish. — For juniors; seniors may elect. Open to other students upon arrangement. Grammar, with special drill in pronunciation; exercises in conversation and composition. Reading from a reader and selected short stories.
3 class hours. Credit, 3.
Associate Professor Mackimmie.

51. **II.** Elementary Spanish. — For juniors; open to other students upon arrangement. As stated in Course 50.
3 class hours. Credit, 3.
Associate Professor Mackimmie.
Prerequisite, Spanish 50.

52. **III.** Elementary Spanish. — For juniors; open to other students upon arrangement. As stated in Course 50.
3 class hours. Credit, 3.
Associate Professor Mackimmie.
Prerequisite, Spanish 51.

75. **I.** Modern Spanish Authors. — Seniors. Reading from modern Spanish novel and drama. Translation of English into Spanish. Private reading.
3 class hours. Credit, 3.
Associate Professor Mackimmie.
Prerequisite, Spanish 52.

76. **II.** Modern Spanish Authors. — Seniors. As stated in Course 75.
3 class hours. Credit, 3.
Associate Professor Mackimmie.
Prerequisite, Spanish 75.

77. **III.** Modern Spanish Authors. — Seniors. As stated in Course 75.
3 class hours. Credit, 3.
Associate Professor Mackimmie.
Prerequisite, Spanish 76.

German and Music.

Associate Professor Ashley, Mr. Julian.

German.

Required Courses.

1. **I.** 2. **II.** 3. **III.** Elementary German. — Freshmen; open upon arrangement to other students. Grammar composition and reading. Especial attention is given to oral work in German and to translation of English into German. Required of those presenting French for entrance who do not continue that language and have not studied German.
3 class hours, each term. Credit, 3 each term.
Associate Professor Ashley and Mr. Julian.

4. **I.** 5. **II.** 6. **III.** Intermediate German. — Freshmen; open upon arrangement to other students. Selected works of Schiller, Heine and Goethe. Grammar review and advanced prose composition.
3 class hours each term. Credit, 3 each term.
Associate Professor Ashley.
Prerequisite, required of freshmen who present two years of German for entrance and do not take French.

Elective Courses.

25. **I.** Intermediate German. — For sophomores; open upon arrangement to other students. Reading of such works as Sudermann's "Frau Sorge," "Wilhelm Tell," "Die Journalisten," etc. Grammar review.
3 class hours. Credit, 3.
Mr. Julian.
Prerequisites, German 1, 2 and 3.

26. **II.** Intermediate German. — For sophomores; open upon arrangement to other students. As stated under Course 25.
3 class hours. Credit, 3.
Mr. Julian.
Prerequisite, German 25.

27. **III.** Intermediate German. — For sophomores; open upon arrangement to other students. As stated under Course 25.
3 class hours. Credit, 3.
Mr. Julian.

Prerequisite, German 26.

28. **I.** Advanced German. — For sophomores; open upon arrangement to other students. Reading and studying of Goethe's most important literature productions.
3 class hours. Credit, 3.
Associate Professor Ashley.

Prerequisites, German 4, 5 and 6.

29. **II.** Advanced German. — For sophomores; open upon arrangement to other students. Development of the German novel; rapid reading of great novelists.
3 class hours. Credit, 3.
Associate Professor Ashley.

Prerequisite, German 28.

30. **III.** Advanced German. — For sophomores; open upon arrangement to other students. As stated under Course 29.
3 class hours. Credit, 3.
Associate Professor Ashley.

Prerequisite, German 29.

Elective Courses.

50. **I.** Scientific German. — For juniors; seniors may elect. Reading in German of modern magazine articles and works of a scientific nature. Different work assigned according to needs of individual students.
3 class hours. Credit, 3.
Associate Professor Ashley.

Prerequisites, German 4, 5 and 6, or German 25, 26 and 27.

51. **II.** Scientific German. — For juniors; seniors may elect. As stated under Course 50.
3 class hours. Credit, 3.
Associate Professor Ashley.

Prerequisite, German 50.

52. **III.** Scientific German. — For juniors; seniors may elect. As stated under Course 50.
3 class hours. Credit, 3.
Associate Professor Ashley.

Prerequisite, German 51.

75. **I.** German Literature. — Seniors. Advanced language and literary study. Conducted entirely in German. Lectures on German literature and history; life, customs and travel in Germany. Collateral readings, including masterpieces of different epochs, such as "Niebelungenlied," Goethe's "Faust" and one modern typical drama.
3 class hours. Credit, 3.
Associate Professor Ashley.

Prerequisites, German 28, 29 and 30.

76. **II.** German Literature. — Seniors. As stated under Course 75.
3 class hours. Credit, 3.
Associate Professor Ashley.

Prerequisite, German 75.

77. **III.** German Literature. — Seniors. As stated under Course 75.
3 class hours. Credit, 3.
Associate Professor Ashley.

Prerequisite, German 76.

78. **I.** Conversation and Composition. — For seniors; juniors may elect. Translating connected English into German. Reproducing outside readings in German orally in class.
1 class hour. Credit, 1.
Associate Professor Ashley.

Prerequisites, German 4, 5 and 6, or German 25, 26 and 27.

79. **II.** Conversation and Composition. — For seniors; juniors may elect. As stated under Course 78.
1 class hour. Credit, 1.
Associate Professor Ashley.

Prerequisite, German 78.

80. **III.** Conversation and Composition. — For seniors; juniors may elect. As stated under Course 78.
1 class hour. Credit, 1.
Associate Professor Ashley.

Prerequisite, German 79.

Music.

Elective Courses.

50. **I.** History and Interpretation of Music. — For juniors; seniors may elect. History of music among the ancients; medieval and secular music; epoch of vocal counterpoint; development of monophony opera and oratorio; life and works of the greatest representatives of the classical school, — Bach, Händel, Haydn, Gluck and Mozart.
1 class hour. Credit, 1.
Associate Professor Ashley.

51. **II.** History and Interpretation of Music. — For juniors; seniors may elect. A continuation of Course 50. The Romantic school; Beethoven, Schubert, Weber, Mendelssohn, Schumann, Chopin, Berlioz and Liszt; Wagner and the opera.
1 class hour. Credit, 1.
Associate Professor Ashley.

52. **III.** History and Interpretation of Music. — For juniors; seniors may elect. The Modern school and Modern composers.
1 class hour. Credit, 1.
Associate Professor Ashley.

DIVISION OF RURAL SOCIAL SCIENCE.

President Butterfield.

[Heavy-faced type indicates the term in which the course is given. Numbering of courses: 1 to 24, inclusive, freshmen; 25 to 49, inclusive, sophomores; 50 to 74, inclusive, juniors; 75 to 99, inclusive, seniors.]

Agricultural Economics.

Professor Cance and Mr. Rutledge.

Required Course.

26. **II.** Agricultural Industry and Resources. — Sophomores. A descriptive course dealing with agriculture as an industry and its relation to physiography, movement of population, supply of labor, commercial development, transportation, public authority and consumers' demand. The principal agricultural resources of the United States will be studied with reference to commercial importance, geographical distribution, present condition and means of increasing the value of the product and cheapening cost of production. Lectures, assigned readings, class topics and discussions.
5 class hours. Credit, 5.
Professor Cance, Mr. Rutledge.

Elective Courses.

50. **I.** Elements of Agricultural Economics. — For juniors; seniors may elect. This course is designed to follow the required work in the elements of economics. It deals with the economic principles underlying the welfare and prosperity of the farmer and those institutions upon which his economic success depends; the economic elements in the production and distribution of agricultural wealth; means of exchange; principles of rural credit; problems of land tenure and land values; taxation of farm property; and the maintenance of the economic status of the farmer. Lectures, text, readings, topics and field work.
5 class hours. Credit, 5.
Professor Cance.

51. **I.** Historical and Comparative Agriculture. — For juniors; seniors may elect. A general survey of agriculture, ancient and modern; feudal and early English husbandry; the later development of English agriculture; the course of agriculture in the United States, with special emphasis on the development of agriculture in New England. An attempt will be made to measure the influence of times, peoples and countries in producing different systems of agriculture, and to ascertain the causes now working to effect agricultural changes. Lectures, readings and library work. Students in education and rural journalism should find this course helpful.
5 class hours. Credit, 5.
Mr. Rutledge.

52. **II.** Co-operation in Agriculture. — For juniors; seniors may elect. The course treats of the history, principles and business relations of agri-

cultural co-operation. (1) A survey of the development, methods and economic results of farmers' organizations and great co-operative movements; (2) the business organization of agriculture abroad, and the present aspects and tendencies in the United States; (3) the principles underlying successful co-operative endeavor among farmers, and practical working plans for co-operative associations, with particular reference to credit and purchase and the marketing of perishable products. Lectures, text, assigned readings and practical exercises.
5 class hours. Credit, 5.
Professor Cance.

75. **I.** The Agricultural Market. — For seniors and graduate students; juniors may elect. A study of the forces and conditions which determine the prices of farm products and the mechanism, methods and problems concerned with transporting, storing and distributing them. Supply and demand, course of prices, terminal facilities, the middleman system, speculation in agricultural products, protective legislation, the retail market and direct sales are taken up. The characteristics and possibilities of the New England market are given special attention. Lectures, readings, assigned studies and field work.
5 class hours. Credit, 5,
Professor Cance.

76. **II.** Transportation of Agricultural Products. — For seniors and graduate students; juniors may elect. This course deals with transportation in the United States, covering highways, waterways, railways and electric ways, with reference to the facilities for and cost of transporting farm products, opening up new agricultural areas or industries, and contributing to the wealth and welfare of the agricultural population. Lectures, text and field work.
5 class hours. Credit, 5.
Professor Cance.

77. **III.** Problems in Agricultural Economics. — For seniors and graduate students; juniors may elect. An advanced course for students desirous of studying more intensively some of the economic problems affecting the farmer. Some of these are: land problems, — land tenure, size of farms, causes affecting land values, private property in land, taxation of farm property; special problems, — cost of producing farm products, farm labor in New England, immigration, agricultural credit. Opportunity will be given, if practicable, for field work, and students will be encouraged to pursue lines of individual interest.
5 class hours. Credit, 5.
Professor Cance.

80. **I.** Seminar. — For seniors and graduate students. Research in agricultural economics and history; problems of New England agriculture. Library work and reports. If desirable some other topic may be substituted. Hours to be arranged.
1 2-hour laboratory period, credit, 1.
The Department.

81. **II.** Seminar. — For seniors and graduate students. As stated in Course 80.

1 2-hour laboratory period, credit, 1.
The Department.

82. **III.** Seminar. — For seniors and graduate students. As stated in Course 80.

1 2-hour laboratory period, credit, 1.
The Department.

Agricultural Education.

Professor Hart.

Elective Courses.

50. **I.** Meaning of Education (Psychology). — For juniors; seniors may elect. For teachers and others desiring an introduction to mental science. A study of the development, structure and functions of the nervous system and the sense organs; the development and nature of mental activities; the nature of the learning processes.

5 class hours. Credit, 5.
Professor Hart.

51. **II.** Rural School Problems. — For juniors; seniors may elect. Primarily for teachers. A study of agricultural education; the theory and practice of teaching; rural school organization; methods of instruction; the place and function of agriculture in the course of study for both rural and city schools; planning and practical work in school and home gardens; planning of equipment and ornamentation of rural school grounds.

2 class hours. 3 2-hour laboratory periods, credit, 5.
Professor Hart.

52. **IV.** Rural School Problems. — For juniors; seniors may elect. As stated under Course 51.

120 laboratory hours, credit, 5.
Professor Hart.

53. **III.** History and Philosophy of Education. — For juniors; seniors may elect. For teachers and others desiring an introduction to educational theories. A study of educational ideals and movements as exemplified by leading nations and races; the growth of educational institutions as influenced by science and industry; the history and meaning of industrial and agricultural education.

5 class hours. Credit, 5.
Professor Hart.

75. **I.** Problems in Rural Education. — For seniors. For teachers or others interested in special phases of education, such as child development, physical and mental; school organization; rural schools; secondary schools; school programs; grading and promotion of pupils; school grounds and school

architecture and equipment; normal schools and the preparation of teachers; agricultural teaching and agricultural schools.
4 class hours. Credit, 4.
Professor Hart.

76. II. Problems in Rural Education. — Seniors. As stated under Course 75.
4 class hours. Credit, 4.
Professor Hart.

77. II. Extension and County Agent Work. — For seniors. The course consists chiefly of library research work. Each student will be required to produce one or more complete lectures under guidance both as to method of preparation and subject-matter, and one or more demonstrations. These lectures will be presented to public audiences in the presence of a board of critics. Some instruction will be given in organization and administration of the Extension Service. The Extension Service will be responsible for the public presentation and criticism. The student's major adviser will be responsible for the accuracy of the subject-matter. The Department of Agricultural Education will be responsible for the preparation of the lectures.
3 class hours. 2 2-hour laboratory periods, credit, 5.
Professor Hart.

78. III. Extension and County Agent Work. — For seniors. As stated under Course 77.
3 class hours. 2 2-hour laboratory periods, credit, 5.
Professor Hart.

Rural Sociology.

Professor Phelan, President Butterfield, Professor Hart, Mr. Novitski.

Required Course.

27. III. Elements of Rural Sociology. — Sophomores. A broad survey of the field of rural sociology, including such topics as the origin of rural sociology, its methods and problems; relation of sociological to the scientific and technical aspects of agricultural problems; the development of the rural community in New England and the west, religious, educational and social ideals of rural people; characteristics and influence of the rural environment, the movement of the rural population, the effects of immigration; rural institutions, the school, the church, local government, effects of modern conditions of life on rural institutions; rural organization; problems of progress, an analysis of the needs of rural life in its further development. Lectures, readings and essays on assigned topics.
3 class hours. Credit, 3.
Professor Phelan, Mr. Novitski.

Elective Courses.

50. I. Social Condition of Rural People. — For juniors; seniors may elect. A. The rural status: composition of the rural population, nature, extent and causes of diseases and accidents, health agencies of control; extent

and causes of rural delinquency and dependency, conditions of temperance of sexual morality and family integrity; child labor, women's work and position; standard of living, size of family; cultural ideals; community consciousness and activity; standards of business conduct and of political ethics.

B. Rural social psychology: characteristics of the rural mind, character of hereditary and environmental influence; nature and effect of face-to-face groups; fashion, conventionality, custom, character of discussion and of public opinion.

3 class hours. Credit, 3.

Professor Phelan.

51. **II.** Rural Government. — For juniors; seniors may elect. A general survey of the development of rural government in the United States; origin of the New England town, its influence upon the west, advantages, development of efficiency, county government, the influence of the farmer in legislation, good roads movement, credit, facilities, taxation, boards of agriculture, agricultural colleges and experiment stations in relation to rural welfare; national government; a general survey of political organizations and movements among farmers in the United States and foreign countries and their influence in shaping legislation; relation of the Department of Agriculture, postal system, the various national commissions and agencies to rural welfare. Lectures, readings, written exercises on assigned topics.

3 class hours. Credit, 3.

Professor Phelan, Mr. Novitski.

52. **III.** Rural Organization. — For juniors; seniors may elect. A study of the organized agencies by which rural communities carry on their various forms of associated life, particularly a study of the ways by which the domestic, economic, cultural, religious and political institutions contribute to rural betterment; principles underlying leadership, qualifications of the paid leader and the lay leader; the field of rural social service, national, State and local, preparation and opportunity for service; rural community building, a study of organized ways and means by which aid is given local communities.

3 class hours. Credit, 3.

President Butterfield.

75. **I. and III.** Farmers' Organizations. — For seniors; juniors may elect. The history, purposes and achievements of the grange, the Farmers' Union, farmers' clubs, village improvement associations, boys' clubs, etc.; the method, scope and history of local, State and national associations formed about some farm product, their influence in forming class consciousness and in shaping agrarian legislation; need of federation. Lectures, readings and essays on assigned topics.

3 class hours. Credit, 3.

Professor Phelan.

76. **I.** Field Work in Rural Sociology. — For seniors; juniors may elect. This course is designed to meet the needs of students who wish to do some constructive work in rural social service while still in college. The work will be carried on in co-operation with the various college agencies engaged in

rural service. Any project for which credit in this course is to be asked must first have the approval of the head of the department.

From 2 to 6 laboratory hours, credits, 1 to 3.
Professor PHELAN.

Prerequisites, Rural Sociology 27 and 52.

77. **II.** RURAL SOCIAL SURVEYS. — For seniors; juniors may elect. A careful study of the theory and function of statistics, the limitations and difficulties in the use of statistics, the interpretation of statistical data, various methods of graphic representation; a study of surveys, kinds and use, method of gaining information, the basis for conclusions, value of information gained. Text and lectures.

3 class hours. Credit, 3.
Professor PHELAN.

78. **II.** RURAL AND BUSINESS LAW. — For seniors; juniors may elect. The work of this course will cover such points as land, titles, public roads, rights incident to ownership of live stock, contracts, commercial paper and distinctions between personal and real property. Text, written exercises, lectures and class discussions.

5 class hours. Credit, 5.
Professor HART.

79. **I.** SEMINAR. — Credits, 1 to 3. Professor PHELAN.

80. **II.** SEMINAR. — Credits, 1 to 3. Professor PHELAN.

81. **III.** SEMINAR. — Credits, 1 to 3. Professor PHELAN.

GENERAL DEPARTMENTS.

Military Science and Tactics.

Capt. H. W. Fleet, Infantry, U. S. A.; Adjutant: Ordnance Sergeant J. J. Lee, U. S. A., retired; Assistant: Quartermaster Sergeant Alex. Smart, U. S. A., retired.

[Owing to the approaching establishment of the Reserve Officers Training Corps, a revision of the statement of work in this department is necessary. It will appear in the spring supplement. The present statement is effective for the college year 1916-17.

The Department of Military Science and Tactics conducts its work in conjunction with the Department of Physical Education and Hygiene, in accordance with the following statement: —

All candidates for a degree in a four-year course must take for three years three full hours a week of physical training. This work must be under college supervision. At least two years of the work must be taken in the Department of Military Science and Tactics, in accordance with the requirements of the War Department; the rest is to be taken in the Department of Physical Education.

Under this arrangement, the practical courses (drill) in military science are given in the first and third terms; the corresponding courses in physical education in the second term.

Under act of Congress (July 2, 1862), military instruction under a regular army officer is required in this college of all able-bodied male students. Men are excused from the exercises of this department only upon presentation of a certificate given by the college physician; minor disabilities which might bar enlistment are not considered. Students excused from military duty may be required to take equivalent work. The object of the instruction is to disseminate military knowledge in order that in emergency trained men may be found to command volunteer troops; but a further object is to give physical exercise, to teach obedience without detracting from self-respect, and to develop the bearing and courtesy that are as becoming in a citizen as in a soldier. Absences and other offences of military nature, and those of which the military instructor may take cognizance as affecting discipline, are dealt with by the commandant in accordance with the regulations of the department; but delinquencies in theoretical instruction not strictly military in their nature are dealt with in accordance with the rules of the faculty.

Cadets in the graduating class who have shown special aptitude for military service are reported to the Adjutant-General of the United States army and to the Adjutant-General of Massachusetts; in making appointments from civil life to the regular or volunteer army, preference is given to those who have been so reported. The names of the three most distinguished are published in the "Official Register of the United States Army." Assignments to the band are made by the military instructor. Practice in the band is credited in place of drill and theoretical instruction.

The required uniform is of olive drab cloth, costing about $17. It is worn by all cadets when on military duty, and may be worn at other times. The uniforms are procured through an authorized tailor. Students upon entering college are required to deposit $17 with the college treasurer to cover the cost of the uniform. The sale of old uniforms is prohibited, unless the consent of the military instructor be obtained.]

[Heavy-faced type indicates the term in which the course is given. Numbering of courses: 1 to 24, inclusive, freshmen; 25 to 49, inclusive, sophomores; 50 to 74 inclusive, juniors; 75 to 99, inclusive, seniors.]

Required Courses.

1. **I.** Tactics. — Freshmen. Theoretical instruction in infantry drill regulations through the battalion and ceremonies. Lectures on military subjects and military history.

1 class hour. Credit, 1.

Captain Fleet.

3. **III.** Tactics. — Freshmen. As stated under Course 1.

1 class hour. Credit, 1.

Captain Fleet.

4. **I.** Drill. — Freshmen. Practical instruction in infantry drill regulations through the battalion. Ceremonies.

3 laboratory hours, credit, 1.
Captain Fleet.

6. **III.** Drill. — Freshmen. As stated under Course 4. Company training in bayonet exercises and physical exercises with and without arms.

3 laboratory hours, credit, 1.
Captain Fleet.

25. **I.** Tactics. — Sophomores. Theoretical instruction in map problems in security and information. Combat. Lectures on military subjects and military history.

1 class hour. Credit, 1.
Captain Fleet.

27. **III.** Tactics. — Sophomores. As stated under Course 25.

1 class hour. Credit, 1.
Captain Fleet.

28. **I.** Drill. — Sophomores. Practical instruction in field service regulations in the service of security and information. Corporals are appointed from this class.

3 laboratory hours, credit, 1.
Captain Fleet.

30. **III.** Drill. — Sophomores. As stated under Course 28; intrenching, combat.

3 laboratory hours, credit, 1.
Captain Fleet.

50. **I.** Military Science. — Juniors. Theoretical instruction in the small-arms firing regulations, in fire discipline, fire control and fire direction.

1 class hour. Credit, 1.
Captain Fleet.

52. **III.** Military Science. — Juniors. As stated in Course 50.

1 class hour. Credit, 1.
Captain Fleet.

53. **I.** Drill. — Juniors. Practical instruction in the small-arms firing regulations in target practice, estimating distances and field firing. Lieutenants and sergeants are appointed from this class.

3 laboratory hours, credit, 1.
Captain Fleet.

55. **III.** Drill. — Juniors. As stated under Course 53.

3 laboratory hours, credit, 1.
Captain Fleet.

Elective Courses.

75. **I.** Military Science. — Seniors. Theoretical instruction in infantry drill regulations, field service regulations, and small-arms firing regulations for company, battalion and regiment.
1 class hour. Credit, 1.
Captain Fleet.

77. **III.** Military Science. — Seniors. As stated under Course 75.
1 class hour. Credit, 1.
Captain Fleet.

78. **I.** Drill. — Seniors. Conduct drills of lower classes. Field officers and captains are appointed from this class. These officers are paid. The positions in every case are obtained by competition. It is to be understood that cadets obtaining these positions will be reported to the Adjutant-General of the army as distinguished cadets.
3 laboratory hours, credit, 1.
Captain Fleet.

80. **III.** Drill. — Seniors. As stated under Course 78.
3 laboratory hours, credit, 1.
Captain Fleet.

Physical Education and Hygiene.

Associate Professor Hicks, Mr. Gore, Mr. Fitzmaurice.

Physical Education.

[The Department of Physical Education conducts its work in physical training in conjunction with the Department of Military Science and Tactics, as explained in the note preceding the description of the courses in military science. All classified undergraduate students are given a physical examination upon entering.]

Required Courses.

1. **I.** Hygiene. — Freshmen. Lectures, reading, quizzes and a report on some assigned topic of personal hygiene or sanitation.
1 class hour. Credit, 1.
Professor Hicks.

5. **II.** Elementary Gymnastics. — Freshmen. Exercises, games and athletics.
3 laboratory hours, credit, 1.
Mr. Gore and Mr. Fitzmaurice.

26. **II.** Graded Gymnastics. — Sophomores. Exercises, games and athletics.
3 laboratory hours, credit, 1.
Mr. Gore and Mr. Fitzmaurice.

51. **II.** Gymnastics. — Juniors. Drills, games and athletics.
3 laboratory hours, credit, 1.
Mr. Gore and Mr. Fitzmaurice.

Elective Course.

77. **III.** Training Course. — Seniors. History of physical education; supervision of indoor and outdoor athletic contests and games; athletic administration.
1 class hour. Credit, 1.
Professor Hicks.

The Graduate School.

The Graduate School.

Kenyon L. Butterfield, A.M., LL.D., President of the College.

Charles H. Fernald, Ph.D., Honorary Director of the Graduate School.

Charles E. Marshall, Ph.D., Director of the Graduate School and Professor of Microbiology.

Graduate Staff, 1916-17.

Professor Anderson, Professor Cance, Professor Chamberlain, Associate Professor Chenoweth, Professor Crampton, Professor Fernald, Professor Foord, Professor Graham, Professor Hart, Dr. Itano, Assistant Professor Jones, Professor Lindsey, Professor McNutt, Associate Professor Nehrling, Professor Osmun, Professor Peters, Professor Sears, Dr. Shaw, Associate Professor van Suchtelen, Professor Waugh, Director Marshall, President Butterfield; Mr. Watts, Secretary.

Graduate courses leading to the degrees of master of science and doctor of philosophy have been given for a number of years; the degrees of master of agriculture and doctor of agriculture are now granted to meet strictly professional needs. The number of requests for each of these courses is apparently increasing. In recognition of the benefits to be derived from a separate organization, a distinct graduate school has been established for the purpose of fitting graduates of this and other institutions for teaching in colleges, high schools and other public schools; for positions as government, State and experiment-station specialists in farm management, dairying, live-stock husbandry, poultry science, agronomy, landscape gardening, pomology, vegetable gardening and floriculture; for positions as bacteriologists, botanists, chemists, entomologists; and for numerous other positions requiring a great amount of scientific knowledge, training and experience.

Organization.

The school is based upon the department as the unit, and the apprenticeship system as the most effective means of instruction. This gives to the student individuality in treatment and an intimacy with actual conditions of work and operations. Besides, each student is assigned to an advisory committee, composed of the instructor in charge of his major subject as chairman, and instructors in charge of his minor subjects as members, which directs his graduate studies. The chairmen of all these committees together constitute the graduate staff, which controls the policy of the graduate school.

Admission.

Admission to the graduate school will be granted: —

1. To graduates of the Massachusetts Agricultural College.

2. To graduates of other institutions of good standing who have received a bachelor's degree substantially equivalent to that conferred by this college.

In case an applicant presents his diploma from an institution of good standing, but has not, as an undergraduate, taken as much of the subject he selects for his major as is required of undergraduates at the Massachusetts Agricultural College, he will be required to make up such parts of the undergraduate work in that subject as the instructor in charge may consider necessary. He shall do this without credit toward his advanced degree.

Admission to the graduate school does not necessarily admit to candidacy for an advanced degree, — students holding a bachelor's degree being in some cases permitted to take graduate work without becoming candidates for higher degrees.

Applications for membership in the graduate school should be presented to the director of the school. Full statements of the applicant's previous training, of the graduate work desired, and of the amount and kind of work already done by him as an undergraduate should be submitted, together with a statement whether the applicant desires to work for a degree.

Registration is required of all students taking graduate courses, the first registration being permitted only after the student has received an authorization card from the director.

Nature, Methods and Requirements of Graduate Work.

Graduate work differs from undergraduate work in its purposes and methods. The primary aims of the instructor are emphasized in an attempt to have the student adjust himself and place himself in his environment; develop the rule of self-direction and self-instruction; acquire the power of accurate reasoning; gain proficiency and skill in his selected field of study or practice; and obtain an appreciative and discriminative insight into experimentation and original research. Methods are not devised, therefore, for attractiveness, entertainment and superficial reviews, but for the creation of initiative and profound thought, thorough acquaintance with detail, independent advance and industrious habits. Careful reading, lectures, conferences, surveys, laboratory exercises and field work are some of the agencies utilized.

All members of the graduate school are required to attend the course of lectures designed to supplement the technical work of all graduate studies. These lectures will be given once each week, and the students will be held responsible for the work.

Candidates for the degree of master of science are required to prosecute two subjects, one of which shall be designated as a major and the other as a minor. These subjects may not be selected in the same department. An original thesis is considered a part of the major subject.

Candidates for the degree of doctor of philosophy are required to prosecute three subjects, one of which shall be designated as the major and the others as minors. No two of these subjects may be taken in the same department. An original thesis shall be considered a part of the major subject.

Candidates for the degree of master of agriculture are allowed greater privileges in the selection of subjects, but will be required to select a major and such other supporting lines of study as will be necessary properly to equip the individual professionally.

Candidates for the degree of doctor of agriculture are required to select a major and such other subjects as will develop the major in its greatest intensity and comprehensiveness. Successful experience is also requisite, together

with a thesis which represents a masterly survey or intimate study through accurate application of some phase of the major subject.

Candidates for membership in the graduate school who do not desire to work for a degree may, with the approval of the director of the school, take more than one subject in the same department, or pursue work in several departments, if their preparation will permit. A statement of the subjects chosen must in each case be submitted to the director of the graduate school for approval by the student's advisory committee. The chosen subjects must bear an appropriate relation to each other.

A working knowledge of French and German is essential to successful graduate work, and students not having this will find it necessary to acquire it as soon as possible after entering.

The graduate staff reserves the privilege of recommending and allowing courses in other institutions as a part of residence instruction. Such supervision will be exercised and credit granted as are essential to the highest standards of efficiency.

Theses.

A thesis is required of each candidate for an advanced degree. It must be on a topic belonging to the candidate's major subject; must show that its writer possesses the ability to carry on original study; and must be an actual contribution to knowledge.

The thesis in its final form, must be submitted to the director by May 15 of the year in which the student is to present himself for the advanced degree, and before he may take the required oral examination. Three complete copies are required. One of the said copies is to be retained as an official copy by the said director, one is to be deposited in the college library, and the third is to be retained by the department in which the thesis was prepared. The candidate for the doctor's degree must be prepared to defend at the oral examination the views presented in his thesis.

Final Examinations.

For the degree of master of science or master of agriculture, final examination, which may be either written or oral, or both, is given upon the completion of each subject.

For the degrees of doctor of philosophy or doctor of agriculture, final examinations on the minors taken are given upon the completion of the subjects. In the major subject, a written examination, if successfully passed, is followed by an oral examination in the presence of the faculty of the school.

Degrees conferred.

The degrees of master of science and master of agriculture are conferred upon graduate students who have met the following requirements: —

1. The devotion of at least one year and a half [1] to the prosecution of study in two subjects of study and research, not less than one full college year of which must be in residence.
2. The devotion of twenty hours [1] each week to the chief or major subject, and of from twelve to sixteen hours per week to the minor subject.
3. The preparation of a thesis in the major subject, constituting an actual contribution to knowledge, and accompanied by drawings if necessary. The thesis may be waived for the degree of master of agriculture.

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[1] All time statements refer to minimum time.

4. The passing of final examinations, in both major and minor subjects, to the satisfaction of the instructors in charge.

5. The payment of all fees and college expenses required.

The degrees of doctor of philosophy and doctor of agriculture are conferred upon graduate students who have met the following requirements: —

1. The devotion of at least three years to the prosecution of three subjects of study and research in residence at the college.

2. The devotion of twenty hours[1] each week to the chief or major subject during the entire period, and of from twelve to sixteen hours per week for a year and a half to each minor subject.

3. The preparation of a thesis, in the major subject, constituting an actual contribution to knowledge and accompanied by drawings if necessary. For the degree of doctor of agriculture the thesis may be modified to meet professional requirements.

4. The passing of final examinations, in both the major and minor subjects, to the satisfaction of the instructors in charge.

5. The payment of all fees and college expenses required.

The fee for the degree of master of science or master of agriculture is $10, and for the degree of doctor of philosophy or doctor of agriculture, $25.

Courses offered.

Courses available as major subjects for the degree of doctor of philosophy: —

Botany.
Chemistry.
Entomology.
Horticulture.
Microbiology.

Courses available as major subjects for the degree of master of science: —

Agriculture.
Agricultural economics.
Agricultural education.
Agronomy.
Animal husbandry.
Botany.
Chemistry.
Entomology.
Horticulture.
Landscape gardening.
Mathematics and physics.
Microbiology.
Poultry science.
Rural sociology.
Veterinary science.

Courses available as major subjects for the degree of master of agriculture: —

Agronomy.
Animal husbandry.
Poultry science.

Courses available as minor subjects for the degree of doctor of philosophy: —

Agriculture.
Agricultural economics.
Agricultural education.
Agronomy.
Animal husbandry.
Animal pathology.
Botany.
Chemistry.
Entomology.
Horticulture.
Landscape gardening.
Microbiology.
Poultry science.
Rural sociology.
Zoölogy.

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[1] All time statements refer to minimum time.

Courses available as minor subjects for the degree of master of science: —

Agriculture.
Agricultural economics.
Agricultural education.
Agronomy.
Animal husbandry.
Animal pathology.
Botany.
Chemistry.
Entomology.
Horticulture.
Landscape gardening.
Microbiology.
Mathematics and physics.
Poultry science.
Rural sociology.
Veterinary science.
Zoölogy.

General Outline of Courses for Advanced Degrees.

Agricultural Economics (Major Course). — 1. Graduate research work in agricultural economics will be developed by four principal methods, namely, historical, statistical, accounting and general field investigation. In all instances the method includes facility in investigation, tabulation and interpretation of results.

2. Candidates for the master's degree, or candidates offering a minor in agricultural economics, will be required to pass an examination covering the undergraduate work now offered in agricultural economics, including Course 50, the elements of economics, Course 75, the agricultural market and Course 52, co-operation in agriculture; and in addition such definite research work as may be outlined by the department, to consist of original investigations in some particular divisions of the subject of agricultural economics. Courses 52, 75, 76 and 77 are for graduates and undergraduates. Special investigations may be made by electing seminars in agricultural economics.

3. Candidates for the master's degree will be required to write a thesis or a report covering results of a specific line of personal investigation in one or more fields of the subject. Each candidate will also be required to have a working knowledge of the general field of economics, the theory of agricultural economics, the problems of agricultural production, land tenure, land problems, agricultural commerce, agricultural co-operation, statistics of agriculture and prices, and markets and marketing.

Agricultural Education (Major Course). — Courses are available in agricultural education as major or minor subjects for the degree of master of science, or, as a minor subject, for the degree of doctor of philosophy. Study will be pursued along one or several of the following lines: —

1. Massachusetts school legislation.
2. Origin and growth of primary, secondary and higher education in Massachusetts.
3. The origin and growth of normal schools, industrial schools and agricultural schools.
4. Educational literature, fiction, periodicals and reports.
5. The physical and mental development of the individual.
6. School administration.

Agronomy (Master of Science). — This course is developed in two directions, depending on whether the candidate is preparing for investigational work or for teaching. In the former case more attention is paid to methods of investigation; in the latter, to interpretation of results. The student may specialize in either Part I. or Part II. of the following: —

I. *Soil Fertility.* — (*a*) The humus problem: Effect of different cropping systems on the humus content of the soil; cultivation, drainage and liming in their effect on soil humus; increase by green manure crops; use of animal manures as sources of humus; conservation of organic matter.

(*b*) The nitrogen question: Losses of nitrogen as occasioned by cropping systems, tillage methods and soil treatment; gain of nitrogen through legumes and other agencies; commercial nitrogen, physiological effect upon the plant, comparison of different forms both in regard to their ultimate as well as immediate effect, amount of application from the business standpoint.

(*c*) Mineral elements of plant food: As above for nitrogen.

(*d*) Lime: Causes of "soil acidity;" comparison of forms of lime; ultimate effect of lime on soil fertility; cost *versus* returns from use of lime.

(*e*) Crop adaptability.

II. *Field Crops.* — (*a*) Distribution, as governed by soil fertility; climatic influences; economic conditions.

(*b*) Kinds and varieties.

(*c*) Cultural methods.

(*d*) Breeding: A knowledge of the principles of breeding is presupposed. With this as a basis, a study of methods, practices and results, as applied to a given crop, must be made.

III. *Thesis.* — The thesis may be taken either in soil fertility or in crop production. In either case a problem for original investigation must be formulated by the candidate, the line of attack developed, the work carried through and results presented in acceptable form.

Literature. — It is required that the candidate familiarize himself with the available literature of the various topics studied.

Animal Husbandry (Master of Science). — *Course A. Animal Breeding.* — 1. Reading: Thorough survey of the scientific works dealing with plant and animal breeding and improvement.

2. Project: Each student must outline and pursue some Mendelian problem.

3. Thesis: This is to be a complete treatise of the problem which the student undertakes; it should be a valuable contribution to the present knowledge of the question of animal breeding

Course B. Animal Nutrition. — This course is in outline similar to A. It is designed to cover the field of nutrition, feeding and management of live stock.

Seminar: Regular periods will be devoted to a discussion of the projects undertaken, together with criticisms of the available material on the question pursued.

Object. — To give the student a comprehensive knowledge of feeding, breeding and management of live stock. This may be divided into a major and a minor, in order to give the student the opportunity of devoting a proportionate share of his time to the class of live stock in which he is particularly interested.

Reading. — The student is to make a very complete survey of experimental and periodical literature dealing with the various phases of the subject.

Practice. — Before the completion of the work for the degree, the student must have the equivalent of at least one year's continuous work on an approved live-stock farm.

Seminar. — Regular periods to discuss progress of the work.

Animal Pathology (Minor Course only). — 1. Reviews in anatomy.

2. Reviews in organography and histology.

3. Special lectures and readings in general and special pathology.
4. Laboratory studies in general and special pathology.
5. Pathological technique.
6. Conferences.

Botany (Major Courses). — The equivalent of certain undergraduate courses, determined in the case of each student by the department, is prerequisite. Candidates for the degree of master of science are required to pass a final examination in writing. A final examination in writing before the department and an oral examination before the graduate staff must be passed by candidates for the degree of doctor of philosophy. Candidates for the latter degree are required to attend all graduate lectures given by the department. Candidates for the degree of master of science will take those lectures given during their period of study in the department. All lecture courses will be given in rotation, except courses (*a*) and (*b*), which will come every year. There will be three lectures a week throughout the fall, winter and spring terms. These lecture courses, outlined below, are designed to cover a period of three years.

(*a*) *Plant Physiology.* — The lectures will consider, under the nutrition of the plant: its chemical structure, absorption of various nutrient substances and their changes in the plant, assimilation and dissimilation of carbon and nitrogen by autotrophic and heterotrophic plants; under changes in the form of plants: growth and form under constant external factors, the influence of variable external and inner factors on growth, form and development; and under plant movements: the various tropisms, nutations, etc. Supplemental demonstrations, laboratory work and readings in the standard texts and journals. One lecture a week for 36 weeks.

(*b*) *Plant Pathology.* — A general consideration of the history, nature and causes of plant disease; parasitism, predisposition, immunity, degeneration, natural and artificial infection, dissemination, epidemics, biologic strains, monstrosities and malformations, proliferation, prevention and control, economics of plant diseases. One lecture a week for 36 weeks.

(*c*) *Normal and Pathogenic Metabolism.* — The lectures in this subject embrace, in more or less detail, comparative consideration of the metabolism of the host in health and disease; the metabolism of the parasite under varying conditions; enzyme activities in host and parasite; methods of preparation and determination of enzyme activities; chemical and physical changes induced in plant tissue by parasites; immunity, etc. Current investigations and new phases of the subjects under discussion will also receive attention as they appear. One hour a week for 24 weeks.

(*d*) *Plant Evolution.* — Consideration of plant life in its inception; differentiation; origin and evolution of sexual and asexual reproduction; variation; heredity and adaptation; phylogenetic relationships. One lecture a week for 24 weeks.

(*e*) *Biologic Relations.* — Consideration of certain phases of the morphological and physiological adaptations of plants with regard to insect visit; the rôle of thorns, hairs, tendrils, glands, etc. Various experiments will be made to test out experimentally some of the existing theories concerning biologic adaptations. One lecture a week for 12 weeks.

(*f*) *The Ecology of Plants.* — This course deals with the water, light and temperature relations of plants, and the various adaptations in response to these factors; the various types of plant formation; the migration of plants;

the competition of plants; invasion and successions of plants under varied conditions; and the various types of alternations and zonations. One lecture a week for 12 weeks.

(*g*) *Physiological Plant Pathology.* — This course considers those plant diseases not due to bacterial or fungous parasites, but resulting from unfavorable physical or chemical conditions of the soil; from harmful atmospheric influences, such as too dry air, too much moisture, hail, wind, lightning, frost; from injurious gases and liquids; from lack of or too much light; from wounds. A knowledge of the normal physiology of the plant is required. Demonstrations and laboratory work will be given, together with assigned readings. One lecture a week for 12 weeks.

(*h*) *History of Botany.* — A historical survey of the science; history of certain culture plants, such as wheat, corn, coffee, potato, rice, and their influence on civilization. One lecture a week for 18 weeks.

Seminar: A weekly seminar for members of the department staff, graduate students and major senior students is held, at which important current botanical papers are discussed. Attendance and participation are required.

Collateral Reading: Extensive reading of botanical literature in English, German and French, designed to give the student a broad knowledge of the science, is required of all major students. Final examinations are based in part upon this reading course.

Thesis: Each major student is required to select a problem in plant pathology or physiology (in other branches at the discretion of the department) for original investigation, and the thesis must embody a distinct contribution to knowledge. An effort will be made to assign problems having some bearing on scientific and economic agriculture.

Professor Osmun, Dr. Chapman, Associate Professor Anderson, Assistant Professor Clark.

Minor Course. — For a minor a student may take such of the work offered by the department as seems best suited to his major course. In most cases no problem will be assigned.

Chemistry. — I. Major courses for the degree of master of science. Students will be required to take Courses 101, 108 to 114. In addition to this the requirements in the various thesis subjects are: —

Organic and Bio-Chemistry. — Courses 115 and either 105, 106 or 107, and 6 hours for one term selected from Courses 103 (*b*) and (*f*), and 104.

Analytical and Industrial Agricultural Chemistry. — Courses 116, 103 (6 hours), and 6 hours for one term selected from Courses 102, 104 to 107.

Physical Chemistry. — Courses 104, 117, and 6 hours for one term selected from Courses 102, 103, 105 to 107.

Agricultural Chemistry. — Courses 103 (6 hours), 118, and 6 hours for one term selected from Courses 102, 104 to 107.

The candidate must pass a final written and oral examination before the Department of Chemistry upon undergraduate Courses 1 to 80, inclusive, and upon all graduate work taken in chemistry by him.

II. Major course for the degree of doctor of philosophy. Students will be required to take Courses 101 to 114, and one course selected from 115 to 118. In addition, the student may be required to spend at least two terms or one semester at some other recognized institution pursuing graduate work in chemistry. The candidate must pass a final written examination before the

Department of Chemistry, and an oral examination before the graduate staff, upon the whole field of chemistry, and must be especially well prepared in the lines of work covered by his research.

III. Minor course for the degrees of master of science and doctor of philosophy. Students will be required to take work totaling 54 to 78 hours. This may be selected from any of the undergraduate Courses 27 and 51 to 80, or any of the graduate courses for which the student is prepared. In addition, the candidate must pass a final written and oral examination before the Department of Chemistry upon the courses taken and upon undergraduate Courses 27 and 51 to 80.

The following is a list of the courses: —

101. *Inorganic Preparations.* — Laboratory. The preparation of chemical products from raw materials. The manufacture and testing of pure chemicals. The laboratory work is essentially synthetic in nature, and is designed to aid in acquiring a more adequate knowledge of inorganic chemistry than is to be obtained by chemical analysis alone. Ten to fifteen of the preparations given in Biltz's "Laboratory Methods of Inorganic Preparations" will be made by each student. Any term, 6 hours. Professor Anderson.

102. *Advanced Inorganic Preparations.* — Laboratory. Continuation of Course 101. Any term, 6 hours. Professor Anderson.

103. *Advanced Analytical Chemistry.* — Laboratory. This course may be taken in part as follows: (*a*) electrolytic analysis, 6 hours; (*b*) ultimate analysis, 6 hours; (*c*) special analytical work to meet the needs of the individual student, 6 hours. In addition, parts of undergraduate Courses 61, 62, 76 and 77 may be taken, as follows: (*d*) fertilizers, 6 hours; (*e*) insecticides, 6 hours; (*f*) milk and butter, 6 hours. (*a*), (*b*), (*c*) may be taken any time; (*d*), (*e*), (*f*) must be taken at the time the undergraduate course is given.
Professor Wellington and Professor Peters.

104. *Advanced Physical Chemistry.* — Laboratory. Measurement of the electrical conductivity of solutions; degree of ionization; ionization constants; per cent. hydrolysis of aniline hydrochloride from conductivity measurements; solubility product by the conductivity method; velocity of saponification by conductivity; neutralization point by conductivity; vapor pressure determinations; critical temperature of carbon dioxide or sulphur dioxide; transport numbers; preparation and properties of colloidal solutions; transition points by dilatometric method; heat of solution of ammonium chloride and potassium nitrate; adsorption of iodine by charcoal; splitting of racemic glycerinic or racemic tartaric acids into their optical components. To each student separate work will be assigned. Any term, 6 hours. Professor Anderson.

105. *Advanced Organic Preparations.* — Laboratory. The preparation of compounds not included in Courses 51 and 52, such as the Kolbe synthesis of salicylic acid; benzophenone and Beckmann's rearrangement; rosaniline, malachite green, congo red, indigo and other dyes; synthesis of fructose; Grignard reaction. Barnett, Cain and Thorpe, Gatterman, Noyes, Fischer and other laboratory guides are used. To each student separate work will be assigned. Any term, 6 hours. Professor Chamberlain.

106. *Advanced Bio-Chemistry.* — Laboratory. The hydrolysis of proteins and isolation of the amino acids; the study of milk, blood and urine; dietary and digestion studies. References: Abderhalden, Plimmer, Salkowski, Hawk, etc. To each student separate work will be assigned. Any term, 6 hours. Professor CHAMBERLAIN.

107. *Industrial Organic Chemistry.* — Laboratory. The preparation, on a large scale, of wood alcohol, acetic acid, ethyl alcohol, benzene and cellulose products, such as mercerized cotton and artificial silk. References: Molinari, Rodgers and Aubert, Thorpe, Enzyklopädie der tech. Chemie, etc. To each student separate work will be assigned. Any term, 6 hours. Professor CHAMBERLAIN.

108. *Theoretical Chemistry.* — Lectures. The following topics are considered: the compressibility of the atoms; the structure of atoms; the electron conception of valence. First term, 1 hour. Given in 1917–18. Alternates with Course 109. Professor PETERS.

109. *Analytical Chemistry.* — A general survey of methods and technique covering processes commonly carried out in the laboratory. Gooch's Quantitative Analysis is used as a text. First term, 1 hour. Given in 1916–17. Alternates with Course 108. Professor PETERS.

110. *Organic Chemistry.* — Lectures. Some of the following topics will be considered both theoretically and industrially: alkaloids, synthetic dyes, essential oils, terpenes, rubber, etc.; the study of methods for carrying out general reactions; isomerism, tautomerism, condensation, etc. References, Cain & Thorpe, Cohen, chemical monographs, Lassar-Cohn, Heinrichs, Molinari. Second term, 1 hour. Given in 1916–17. Alternates with Course 111. Professor CHAMBERLAIN.

111. *Bio-Chemistry.* — Lectures. Some of the following topics will be considered both chemically and physiologically: fats, cholesterol, lecithin, carbohydrates, amino acids, proteins, urea, uric acid, purine bases, enzymes, fermentation, animal food and nutrition, photosynthesis. References, Monographs on Bio-Chemistry, Abderhalden, Plimmer, Haas & Hill, Lewkowitsch, Fischer, Euler, Mathews, Czapek. Second term, 1 hour. Given in 1917–18. Alternates with Course 110. Professor CHAMBERLAIN.

112. *Theoretical and Physical Chemistry.* — Lectures. The relation between the constitution and properties of compounds; mutarotation; steric hindrances; stereoisomerism of other elements than carbon; molecular association; similarity between the compounds of silicon and carbon. Third term, 1 hour. Given in 1917–18. Alternates with Course 113. Professor ANDERSON.

113. *Theoretical and Physical Chemistry.* — Lectures. Radioactivity; the application of physical chemistry to industrial chemistry. Third term, 1 hour. Given in 1916–17. Alternates with 112. Professor ANDERSON.

114. *Seminar.* — Conferences, reports or lectures. Three terms, twice a month, 1½ hours. Professor LINDSEY.

115. *Research in Organic and Bio-Chemistry.* — Three terms. A minimum of 20 hours' laboratory work per week. Credit determined by amount of work done. Professor CHAMBERLAIN.

116. *Research in Analytical or Agricultural Industrial Chemistry.* — Three terms. A minimum of 20 hours' laboratory work per week. Credit determined by the amount of work done.
Professor WELLINGTON and Professor PETERS.

117. *Research in Physical Chemistry.* — Three terms. A minimum of 20 hours' laboratory work per week. Credit determined by amount of work done.
Professor ANDERSON.

118. *Research in Agricultural Chemistry.* — Three terms. A minimum of 20 hours' laboratory work per week. Credit determined by amount of work done. Professor LINDSEY and EXPERIMENT STATION ASSOCIATES.

ENTOMOLOGY (Major Courses, Ph.D. degree). — 1. *Morphology.* — Lectures on all, and laboratory work on a portion of the following subjects: embryology and polyembryology; transformations; histology; phylogeny; hermaphroditism; hybrids; parthenogenesis; pedogenesis; heterogamy; chemistry of colors; coloration; luminosity; deformities; variation.

2. *Ecology.* — Lectures and laboratory work as above on the following subjects: dimorphism; polymorphism; protective devices; mimicry; psychoses; insect architecture; plant fertilization; insect products; geographical distribution; methods of distribution; migration; geological history; insects and disease; enemies of insects, vegetable and animal; duration of life; experimental entomology.

3. *Economic.* — Lectures and laboratory work as above on the following subjects: special methods of control; insecticides; special research; insect photography; methods of preparing illustrations; field work and life-history investigations; insect legislation; methods of record keeping.

4. *Systematic.* — Lectures and laboratory work as above on the following subjects: history of entomology; classifications and principles of classification; nomenclature and its rules; how to find and use literature; preparing indices; number of insects known and in existence; lives of prominent entomologists; methods of collecting, preparing, preserving and shipping insects; important collections; location of types.

5. Seminar; required readings; thesis.
Professor FERNALD, Professor CRAMPTON, Dr. REGAN.

All of these five courses are required of students taking a Ph.D. in entomology.

Minor Courses. — Such portions of the major courses as are most closely correlated with the other lines of work taken by the student and which can be completed in the time available.

Horticulture. — Graduate work is offered in various lines of horticulture. For the most part this is divided into the different departments which now constitute the college Division of Horticulture, as follows: pomology, floriculture, landscape gardening, forestry and market gardening. For work in these lines application should be made direct to the heads of the several departments.

Besides this work, however, opportunity is offered for graduate study in general horticulture, including topics from the several organized departments mentioned, and also questions relating to plant breeding, general evolution, propagation, manufacture of horticultural products, etc. This general work is under the direction of Prof. F. A. Waugh, head of the Division of Horticulture.

Landscape Gardening (Major Course). — Every student before receiving his master's degree in landscape gardening must have given some thorough and fruitful study to each of the following five departments. As far as possible these studies must be of a practical nature, *i.e.*, they must be made upon actual projects in progress of development.

1. *Theory.* — The principles of esthetics as applied to landscape gardening.
2. *Design.* — The principles of pure design and their application in landscape and garden planning.
3. *Construction.* — The practical methods of carrying out landscape plans, laying out, equipment, organization of working force, time and cost keeping, etc.
4. *Maintenance.* — Methods, organization, cost.
5. *Practice.* — Office work, drafting, estimating, reporting, charges, accounting.

Qualifications. — Each student before he may receive the master's degree with a major in this department must convince his instructors that he has a genuine aptitude for some branch of landscape gardening, either in design, construction or management.

The minimum period of graduate study will be one and one-half years. At least one year of this time must be spent in residence at the college, and also one year must be spent in practice outside the college. The work done outside the college may be prescribed by the department, and must be fully reported to the department in writing. It is essential, further, that the candidate secure the written approval of his employers outside the college. The department may, at its discretion, require a longer period of study at the college or a longer apprenticeship outside the college.

Thesis or Project. — Each student before receiving the master's degree with a major in landscape gardening must present a satisfactory thesis or complete project. A thesis will consist of a careful original study of some problem in landscape architecture, presented in typewritten form with any necessary illustrations, such as photographs, diagrams, drawings, etc. A project will consist of a completed set of studies of some suitable landscape-gardening problem, such as the design of a park, a real estate subdivision, an extensive playground. Such a project will usually consist of —

(*a*) Original surveys, including topography.
(*b*) Block plans, showing original design.
(*c*) A rendered plan or plans of the main features.
(*d*) Detailed working drawings.

(*e*) Estimates of cost.

(*f*) Complete report and letter of transmittal.

Minor Course. — Any student electing a minor in landscape gardening will be directed to take such courses from the regular catalogue list as may seem most suitable for him. Under ordinary circumstances no other work will be given to students electing minors. In special cases, however, individual problems will be assigned and individual instruction given. These exceptions will be made in cases where, by so doing, it is possible to give the student material assistance in the plan of his major work.

Prerequisite Work. — The undergraduate courses in the college known as Landscape Gardening 50, 51, 52 and 53, Drawing 25, 26, 27, Horticulture 27, 50, 51, and Mathematics 26 and 27 will be considered prerequisite to graduate work, and any student not having passed these courses or their equivalent will be required to make up such work without graduate credit. Courses known as Landscape Gardening 75, 76, 77, 78 and 79 are required and may or may not be accepted for graduate credit, at the discretion of the department.

Microbiology (Major Course). — 1. *Reading.* — Readings will be assigned and reports with critical analyses of literature covering the general subject will be required. For this purpose such material will be selected as will be most pertinent to the needs of the student. Lectures will be given from time to time.

2. *Seminar.* — At intervals the immediate laboratory work and studies of the student will be surveyed and the literature bearing thereon will be discussed. The shaping of investigations in accordance with the critical analyses of the specific literature of the problem involved will be the important rôle of the seminar.

3. *Morphological and Cultural Studies.* — Special advanced studies in the cytology, morphology and cultural characters of micro-organisms will be the general theme of this course. The important factors in classifying and grouping organisms call for an intimate knowledge of this particular phase of microbiology. Laboratory technic will receive emphasis.

4. *Physiological Studies.* — The changes produced by micro-organisms and their functionings in general open a very broad field for investigation and systematic study. It is advised that every graduate student in microbiology give much attention to this branch, gaining thereby the greatest comprehensive knowledge of physiological processes, as well as the methods employed in their determinations.

5. Special advanced courses will be offered in those phases of microbiology indicated by the undergraduate courses: —

1. Fermentation microbiology.
2. Soil microbiology.
3. Dairy microbiology.
4. Food microbiology.
5. Hygienic and sanitary microbiology.

It will be assumed that all graduate students of microbiology must be acquainted with the details of all important phases of agricultural microbiology.

Minor Course. — 1. Courses constituting undergraduate major in microbiology, or their equivalent, will be required.

Note. — If the student is familiar with the work of these courses, advanced work will be given in accordance with the graduate major outline.

2. Emphasis will be placed upon that particular phase of microbiology which will be particularly pertinent to the student's major course.

3. Readings will be assigned, and will be reviewed in conferences.

4. Special lectures on selected subjects in microbiology will be given from time to time.

Poultry Science (Major Course for the Degrees of M.S. and M.Agr.). — 1. *Reading.* — A review of the entire field of poultry literature, covering books, bulletins and special articles, is made, and a written report on one or more subjects required.

2. *Seminar.* — A critical review and a criticism of the more important experiments carried on at the various stations in this and other countries; also a study of poultry conditions in foreign countries, methods of management, etc., besides a detailed study of some of the largest poultry projects in this country.

3. *Anatomy (Gross and Histological), Physiology and Surgery.* — This course requires a careful study of the anatomy and physiology of the fowl. Special attention is given to a study of those structures concerned with practical poultry problems. Instruction in surgical technique, adapted to fowls, may also be given.

4. *Breeding.* — The student will carry on such breeding experiments as time and facilities permit. He may also do work in connection with our regular experimental projects. A detailed study of the pertinent literature will be required. Animal Husbandry 5, or its equivalent, is a prerequisite.

5. *Feeding.* — A study of the relation of various foods and other substances to the morphology and physiology of the bird, with special reference to such subjects as egg production, feather form and structure, condition of flesh, bone, etc.

6. *Brooding.* — Studies will be made upon the relation between viability and rate of growth and the following topics: type of brooder, number of chicks in brood, ventilation, humidity, sanitation, exercise and weather conditions; also a comparison of natural methods with artificial methods of rearing chicks.

7. *Incubation and Embryology.* — A number of problems of a practical, scientific and mechanical nature relating to incubation are considered. The work in embryology is of an advanced nature dealing with its relation to morphogenesis and heredity, and presupposes an elementary knowledge of the embryology of the chick.

8. *Poultry Diseases and Sanitation.* — In this course a study is made of various problems in poultry sanitation, with particular reference to methods relating to the control and eradication of disease.

9. *Thesis.* — A thesis based on first-hand work on some problem in poultry biology or husbandry is required of all students working for the M.S. degree, and may be required of those working for the M.Agr. degree.

Note 1. The postgraduate course presupposes all undergraduate work or its equivalent, together with practical experience. Without the latter, students will be unable to handle Courses 5, 6 and 7. At the discretion of the instructor in charge, graduate students may be required to pursue undergraduate courses in other departments without credit.

Note 2. Practical poultry work may be required, but no credit will be given for such work.

Note 3. Courses 1 and 2 are designed particularly for minors.

Rural Sociology. — Courses are offered in Rural Sociology as major or minor subjects for the degree of doctor of philosophy.

Candidates for the master's degree will be required to pass an examination in all courses offered by this department primarily for undergraduates, as shown in the departmental classification. In addition they will be required to select one or more of the divisions of the subject for intensive study and research, as indicated below.

A thesis showing the results of personal investigation on some particular topic or topics must be presented. The thesis must show familiarity with the material bearing on the subject, ability in discovering and utilizing original sources, judgment in evaluating facts, evidences and authorities, originality and independence of thought. It must be a contribution in a very definite way to rural sociological thought.

Topics for Study and Research.

1. The rural community: —
    - (a) Historical development.
    - (b) Influence of modern conditions on family and community life.
    - (c) Problems and methods in community organization.
    - (d) Community planning in Massachusetts.
2. Origin and development of rural institutions: —
    - (a) Scope, function and influence of educational institutions on rural social progress. Plans for betterment.
    - (b) History of the development of the rural church, its problems and program for improvement.
    - (c) The farm family, in its relation to religious, cultural, educational and social agencies. The relation of the standard of living to rural social progress.
3. Rural organization: —
    - (a) The scope and function of rural organization in development of rural life.
    - (b) Work of the national government in rural organization.
    - (c) County and institutional work in rural organization.
    - (d) Leadership in its relation to organization.
4. Rural government and rural law: —
    - (a) Development of rural local government in New England and the west. Progress in efficient local self-government.
    - (b) Relation of the State to the farmer, influence of the farmer in legislation, the organized ways and means by which the State aids the farmer directly.
    - (c) Work of the national government in its relation to the social welfare of the farming people.
    - (d) Agrarian legislation in the United States and Europe affecting rural social welfare.
5. Farmers' organizations: —
    - (a) Social problems underlying farmers' organizations in reference to service and permanency.
    - (b) Principles of organization.
    - (c) History of farmers' organizations in the United States.
6. Rural social and sociological surveys: —
    - (a) An intensive study of the place and function of statistical data in the sociological field, its evaluation and interpretation.
    - (b) A critical study of social surveys of rural life and methods of survey, with a view to discovering the strength and weakness of each.
7. Social condition of the rural people: —
    - (a) Origin and development of rural ideals.
    - (b) The status of the rural people in relation to health, morality, crime, etc.
    - (c) Problems of social psychology arising in rural life.

The course required for candidates offering a minor will be arranged after a conference with the director of the department, and will take into consideration the needs of the student in view of his previous preparation. The

amount of time required of the student for his minor work will correspond with the requirements of the graduate school.

Veterinary Science. — Work is available in anatomy, hygiene, veterinary pathology, medicine, surgery, parasitology and other special lines or divisions of the subject.

Zoölogy. — Courses in zoölogy may be available as a minor for the degree of master of science and as a minor for the degree of doctor of philosophy. The nature of the work will necessarily vary according to circumstances, and may be intensive in a special field, like that of embryology or economic ornithology, and be correlated closely with the major work of the student, or it may be of a more general character, depending on the student's needs or previous acquaintance with general zoölogical science. The time devoted to zoölogy as a minor for either of the above-named degrees may vary from 12 to 16 hours per week, pursued for a year and a half.

List of Students.

A list of the degrees conferred in the Graduate School, and of the students enrolled, is given in the general lists at the end of the volume.

The Short Courses

and

The Extension Service.

THE SHORT COURSES.

The short courses offered by the Massachusetts Agricultural College are designed to meet the needs of those who cannot come to the college for the regular academic courses. They furnish the student with instruction in modern accepted methods, and are made as concentrated and as practical as possible. In the main, the instruction is given by the regular teaching force of the college, the same laboratories and equipment being used as in the regular college work.

The short courses may be grouped as follows: —

A. Winter Schools.
   1. Ten Weeks' Course.
   2. Spring Beekeeping School.
   3. Apple Packing School.

B. Summer Schools.
   1. Summer School of Agriculture and Country Life.
   2. School for Rural Social Service.
   3. School for Library Workers.

EXPENSES OF THE SHORT COURSES. — The expense of attending any of the short courses is approximately as follows: —

Registration fee (Ten Weeks' Course, Apple Packing School, Summer School),	$5
Furnished rooms in private houses (per week),	$1.50–$3
Board at college dining hall (per week),	$4.50–$5
Board with private families (per week),	$6–$7

A lunch counter is operated in connection with the college dining hall. Meals may be obtained there *à la carte* at very reasonable rates.

Students in each of the dairy courses must provide themselves with two white wash suits and caps for use in the practical dairy work. The cost in Amherst is about $1.25 for suit and cap.

REQUIREMENTS FOR ADMISSION TO SHORT COURSES. — No entrance examinations are required, but students are advised to review their school work in English and arithmetic. Practical experience in farm, garden, orchard or greenhouse work is an advantage. The courses are open to both men and women.

Students must be at least eighteen years of age, and must furnish satisfactory evidence of good moral character. References are required, and these are investigated before applicants are accepted.

A. WINTER SCHOOLS, 1917.

1. OUTLINE OF THE TEN WEEKS' COURSES (JANUARY 1 TO MARCH 9, INCLUSIVE). — The following courses are offered: —

1. Soil Fertility. Assistant Professor JONES. Three lectures a week.
2. Field Crops. Assistant Professor JONES. Two lectures and one two-hour laboratory period a week.

3. Types and Breeds of Live Stock. Professor McNutt. Three lectures and two two-hour judging periods a week.
4. Live Stock Feeding. Assistant Professor Quaife. Three lectures a week.
5. Animal Breeding. Professor McNutt. One lecture and one two-hour laboratory period a week.
6. Dairying. Professors Lockwood and Jamison, Mr. Coons. Five lectures and one one-hour, two two-hour and two three-hour laboratory periods a week.
7. Dairy Bacteriology. Professor Marshall. Two lectures a week.
8. Animal Diseases and Stable Sanitation. Professor Paige. Two lectures a week.
9. Poultry Husbandry. Professor Graham and Mr. Payne. Five lectures and one two-hour laboratory period a week.
10. Farm Management and Farm Accounts. Professor Foord. One lecture and one two-hour laboratory period a week.
11. Fruit Growing. Professor Sears. Three lectures and one two-hour laboratory period a week.
12. Market Gardening. Assistant Professor A. S. Thomson. Three lectures and two two-hour laboratory periods a week.
13. Landscape Gardening. Assistant Professor Harrison. Two two-hour periods a week.
14. Floriculture. Associate Professor Nehrling. Three lectures a week; field trips on Saturday.
15. Forestry. Professor Clark. One lecture a week.
16. Botany. Assistant Professor Anderson. Two lectures a week.
17. Entomology. Dr. W. S. Regan. Three lectures a week.
18. Beekeeping. Associate Professor Gates and Mr. Byard. Two lectures and one two-hour laboratory period a week.
19. Farm Mechanics. Professor Gunness. One lecture and one two-hour laboratory period a week.
20. Rural Sanitary Science. Professor Marshall. Two lectures a week.
21. Rural Improvement. Professor Waugh. Two lectures a week.
22. Problems of Marketing and Distribution. Professor Cance. Two lectures a week.

1. Spring Beekeeping School. — This school is held in Amherst once in three years, being conducted in other sections of the State in intervening years. It is an intensive course for a limited number of beekeepers. It occupies seven hours daily for a period of two weeks. Courses are given in practical beekeeping; life of the honeybee; special problems of the beekeeper; crops foraged by bees; relation of bees to pollination of plants; bees in horticultural practice. The instructors are Professors Gates, Fernald, Paige, Brooks, Osmun and Chenoweth and Mr. Byard. Dates to be announced.

2. Apple Packing School. — The work of this school, which is conducted by the Department of Pomology, is of a practical nature, and includes both box and barrel packing. Persons taking the course will become familiar with the various types of packs, and will receive sufficient practice to enable them to do good commercial packing. The 1917 school will probably be held in November, on dates to be announced.

B. Summer Schools.

1. The Summer School of Agriculture and Country Life. — The Summer School of the Massachusetts Agricultural College will open July 2, 1917, for a term of four weeks. The work of the summer school was designed originally for teachers, and the attendance has been largely of that class. Special attention will be given to the needs of teachers again this year. It has been found, however, that there are many persons who seek a general knowledge of theoretical and practical agriculture, and who can come to the college conveniently during the summer season. Practical courses are offered for the benefit of such persons.

The formal instruction in the summer school is given in definite courses. Each student may elect not less than 10 nor more than 15 exercises a week, unless a larger or smaller amount of work is allowed by the supervisor. These courses include a large amount of field work, observation trips, outdoor exercises and laboratory experiments.

General field exercises are arranged for one afternoon of each week. These are on topics of interest to all. Excursions are arranged for every Wednesday afternoon, and more extended excursions for the whole school are planned for every Saturday. These excursions are in charge of an instructor. In the past they have proved a very enjoyable feature of the work. Round-table and special discussions are arranged by the various instructors as their courses require.

A course of evening lectures on popular topics relating to the work of the school is a feature of the general program. This lecture course is free to all students.

Early registration is desirable. Registration fee for the summer school is $5, payable at the time application is made. No other tuition is charged. This fee should accompany application blank and should be made payable to the Massachusetts Agricultural College.

2. The School for Rural Social Service. — The Massachusetts Agricultural College offers a School for Rural Social Service in connection with the usual Summer School of Agriculture and Country Life. The courses offered give instruction, furnish information and direct the attention of those interested more particularly to the rural field, which has as yet received little systematic study when compared with that which has been given to urban conditions.

The courses offered are intended for clergymen, teachers, librarians, town officers, grange workers and others who devote a considerable portion of their time to problems of community development. Other courses given in the summer school during this period are also open to those who register. There is a registration fee of $1 for those attending this school. The dates are to be announced.

3. School for Library Workers. — During the summer of 1915 a very successful School for Library Workers, of one week's duration, was held at the college. The work was planned especially for those librarians and library assistants in village and rural libraries whose special training and experience had necessarily been limited. This school will again be offered in July, 1917.

The faculty of the 1916 summer schools was as follows: —

Kenyon L. Butterfield, A.M., LL.D., President of the College.
William D. Hurd, M.Agr., Director of the Extension Service and Supervisor of Short Courses.
Charles R. Green, B.Agr., Librarian of the College.
F. Josephine Hall, A.M., Adviser for Women.
John L. Byard, Superintendent of Apiary.
Alexander E. Cance, Professor of Agricultural Economics.
Walter W. Chenoweth, M.Sc., Associate Professor of Pomology.
William D. Clark, A.B., M.F., Professor of Forestry.
Laura Comstock, Extension Professor of Home Economics.
Samuel Coons, Instructor in Dairying.
E. Farnham Damon, B.Sc., Extension Associate Professor of Agricultural Economics.
Henry T. Fernald, Ph.D., Professor of Entomology.
James A. Foord, M.Sc.Agr., Professor of Farm Administration.
Burton N. Gates, Ph.D., Associate Professor of Beekeeping.
Helena T. Goessmann, M.Ph., Instructor in English.

Harold M. Gore, B.Sc., Assistant in Physical Education.
John C. Graham, B.Sc., Professor of Poultry Husbandry.
Edna A. Post, Organized Play.
Ida E. Hall, LL.B., Plays and Pageantry.
Earl Jones, M.Sc., Assistant Professor of Agronomy.
William P. B. Lockwood, M.Sc., Professor of Dairying.
Frederick A. McLaughlin, B.Sc., Instructor in Botany.
John C. McNutt, B.Sc.Agr., Professor of Animal Husbandry.
Charles J. Maynard, Naturalist and Lecturer, West Newton, Mass.
Orion A. Morton, Extension Professor of Agricultural Education.
Ezra L. Morgan, A.M., Extension Professor of Community Planning.
Ethel H. Nash, Extension Instructor in Agricultural Education.
Arno H. Nehrling, Associate Professor of Floriculture.
A. Vincent Osmun, M.Sc., Associate Professor of Botany.
Samuel R. Parsons, B.Sc., Instructor, Pennsylvania State College.
Charles A. Peters, PhD., Associate Professor of Inorganic and Soil Chemistry.
Frederick W. Ried, Director of Practical Arts, Framingham (Mass.) Normal School.
Marie Sayles, B.S., Extension Instructor in Home Economics.
F. A. Cushing Smith, B.Sc., M.L.A., Extension Instructor in Civic Improvement.
Leone E. Smith, B.Sc., Superintendent, Colchester (Conn.) Boys' Club.
Frank A. Waugh, M.Sc., Professor of Landscape Gardening.
Willard E. Waterbury, Field Secretary, Massachusetts Baptist Missionary Society, Boston.

C. Miscellaneous Short Courses.

1. Short Courses for Special Groups. — Plans are now under way to provide short courses at Amherst, lasting four or five days, for fertilizer agents, feed agents and dealers, milk inspectors, seed dealers, bankers and other groups desiring such instruction. Information concerning these may be obtained by writing the Supervisor of Short Courses.

2. Special Days for Foreigners. — Each year there are provided at the college special days for foreigners. Instruction is given in soil management, co-operation, American citizenship and history. This work for foreigners will be arranged at the college, or in different sections of the State.

3. Meetings of Organizations at the College. — It is customary for the various State organizations of fruit growers, poultrymen, breeders and others to meet for conventions and picnics at the college. Such gatherings are welcomed by the college authorities, and organizations are cordially invited to meet in Amherst. The Extension Service will assist in arranging programs and other forms of instruction and entertainment.

All requests for announcements or further information regarding any of the short courses should be addressed to the Supervisor of Short Courses, Massachusetts Agricultural College, Amherst, Mass.

THE EXTENSION SERVICE.

What is known as the Extension Service is an organized effort on the part of the college to carry systematic and dignified instruction to the thousands of people throughout the State who are unable, owing to various reasons, to take advantage of the regular courses offered at the college. It is in reality the "carrying of the college to the people of the State." Every department of the institution, in so far as the regular teaching and research work will permit, contributes what it can to this work. The work may be roughly classified under the following general heads: general administration; correspondence study; itinerant instruction which includes lectures and lecture courses, exhibits, demonstrations and extension schools; extension work through the various departments of the college, in which the extension specialist is responsible to the head of the department for the technique of the work and to the director of the extension service for the accomplishment of the work; co-operative work of various kinds with the United States Department of Agriculture; and extension work through county, district and local agents. Some of the ways in which this is being done are described briefly below.

COURSES GIVEN AT THE COLLEGE.

1. FARMERS' WEEK. — In order to reach those who cannot come to the college for a longer time this very practical course, five days in length, is given each year. The regular college equipment is used, and work of the regular faculty is supplemented by lectures and demonstrations by eminent men and women.

The 1917 program will probably be divided into seven sections, as follows: —

1. Field Crops and Farm Management.
2. Animal Husbandry and Dairying.
3. Poultry Husbandry.
4. Fruit Growing, Market Gardening, Floriculture, Forestry.
5. Women's Section, Home Economics.
6. Business Organization and Marketing.
7. Beekeeping.

These sections take up the time from early morning until late afternoon. Prominent men are engaged for the evening lectures. Fruit, corn, live stock, dairy and poultry shows, and other exhibits, are among the leading features. No fee is charged.

2. ANNUAL BEEKEEPERS' CONVENTION. — This convention of beekeepers is held during Farmers' Week. Illustrated lectures, practical demonstrations and commercial displays are features of the convention. Meetings of State and county beekeepers' associations and of apiary inspectors also are scheduled at this time.

3. Polish Farmers' Day. — A special day is each year set aside which is known as "Polish Farmers' Day." Instruction is given relative to the crops and animals in which the Polish people are most interested, soil fertility problems, co-operation, American citizenship, history, etc. Hundreds of Polish farmers reside in the Connecticut valley, and large numbers avail themselves of this opportunity which is peculiarly their own. It will be held on March 22, 1917.

4. Annual Conference of County Agents and Vocational Agricultural Instructors. — In December of each year a one-week conference of county agents and vocational agricultural instructors is held at the college. This is for the purpose of correlating the extension work throughout the State, and to enable the field workers to keep in up-to-the-minute touch with agricultural problems, methods and research as conducted in Massachusetts as well as other States in this particular section of the country. The next annual conference will probably be held during the third full week in December, 1917.

5. Poultry Convention. — In order to give a large number of poultrymen, who cannot come to the college for a long period of time, practical instruction in modern methods of breeding, feeding, poultry-house construction, operation of incubators and brooders, selecting and judging poultry for utility and for show, and in marketing poultry products, an annual three-day convention is offered. This will be held from July 25 to 27, 1917, inclusive.

6. Agricultural Camps. — During the month of July three camps are arranged in order that boys from rural districts and small towns may receive some instruction in agriculture and clean, wholesome sports, and that they may have impressed upon them their responsibilities as coming members of society. The daily program consists of camp duty, flag raising, agricultural lessons, talks on hygiene and good citizenship, play and recreation, instruction in handicrafts, photography, evening camp fires and lectures by men prominent in boys' work. A small fee is charged to help defray the cost of board and incidental expenses. As a third prize in the State-wide boys' and girls' clubs a week in camp at the college is offered. The third boys' camp is given over to these prize winners, usually 35 to 40 in number. A separate camp, upon a slightly different plan and under different supervision, is held for the girl prize winners of the previous year.

7. Conference on Rural Organization. — This conference is held as a closing feature of the summer school each year. It takes up various problems of New England country life. Numerous State organizations co-operate with the college in providing the programs. Section meetings of various groups are held each forenoon, a general round-table discussion is held each afternoon, and lectures are delivered each evening by persons prominent in social and educational work. Many small group conferences are also arranged. This conference will follow immediately after the summer school.

Correspondence Courses. — The purpose of the correspondence courses is to furnish systematic instruction in those lines which will most benefit the general farmer, the dairyman, the fruit grower, the market gardener, the poultryman, the teacher, the homemaker, and all others who are interested in agricultural and country-life matters. It is the purpose to present up-to-date, accurate and concise information in such a manner and in such language that all who pursue the study may readily understand the work.

Courses offered. — A number of courses are in process of revision and several are being rewritten. During 1917 courses will be available as follows: —

1. Soils and Soil Fertility. Assistant Professor JONES.
2. Manures, Fertilizers and Soil Amendments. Assistant Professor JONES.
3. Field Crops Assistant Professor JONES.
4. Farm Dairying. Professor LOCKWOOD.
5. Fruit Growing. Professor SEARS, Associate Professor CHENOWETH.
6. Market Gardening. Assistant Professor A. S. THOMSON.
7. Animal Feeding. Mr. TURNER.
9. Farm Accounts. Professor FOORD.
10. Entomology. Dr. REGAN.
12. Beekeeping. Associate Professor GATES.
13. Forestry. Professor CLARK.
14. Shade Tree Management. Professor OSMUN.
17. Poultry Husbandry. Professor GRAHAM.
18. Home Economics. Extension Professor COMSTOCK.
19. Rural Sociology. Professor PHELAN.

Methods of conducting the Work. — The best known methods of conducting correspondence course teaching are employed. Certain courses are based entirely upon text-books, others consist wholly of typewritten lectures, while others combine the two. If books are not required they are usually recommended.

The courses are designed primarily for the individual student. A new phase of the work, however, is the organization of study clubs or classes, meeting together periodically and using the courses as a basis of study. Correspondence in regard to this work is invited.

Enrollment of Correspondence Courses. — Students may enroll in the courses at any time between October 1 and June 1, and one year from the date of registration is allowed for the completion of each course. It has been found advisable to discontinue the courses through the summer months, as farmers and most other students cannot devote the necessary amount of time to the lessons during this season.

Expenses of the Correspondence Courses. — In order that none shall enroll except those who are interested and desire to pursue earnest study, a small fee is charged. This has been fixed at $1 for each course except where the courses are divided, and it has been found advisable to charge $1 for each of the parts in these instances. The fee is payable strictly in advance, at the time the enrollment card is sent. When text-books are required the student purchases these.

MISCELLANEOUS SHORT COURSES. — For certain such courses, see page 150.

LECTURES AND DEMONSTRATIONS. — The members of the faculty of the college are, when other duties will permit, available for lectures and demonstrations before granges, men's clubs, women's clubs, Y. M. C. A.'s, farmers' clubs, boards of trade and other organizations. A list of more than 40 lecturers and 200 subjects on various phases of agriculture, country life, economics, sociology, education, civic betterment and various scientific subjects has been prepared. Full courses of lectures or single lectures may be arranged.

Organizations arranging the lectures are asked to pay the traveling expenses of the lecturer, provided no admission fee is charged. When admission is charged the lecturer is entitled to a fee in addition to traveling expenses.

EXTENSION SCHOOLS. — The extension schools are of two distinct types, the first being the Agricultural Extension School, dealing with the production side of farming and with the problems of the farm home; the second is the Extension School in Community Planning, having to do with the organization and selling end of agriculture, and with instruction in the planning and carrying forward of various community activities.

It is also possible to arrange special extension schools along one particular line of work, such as fruit growing, dairying, etc.

Communities desiring an extension school make a written request, agreeing to defray all local expenses, such as the rent, heating and lighting of a suitable hall, and the board of the instructors during the school.

Agricultural Extension Schools. — The college sends a corps of instructors to a town for a five-day school of instruction. At present the following courses are offered: soil fertility, animal husbandry and dairying, fruit growing, poultry husbandry and vegetable gardening for the men, and a homemakers' course for the women. Morning and afternoon sessions only are held.

Community Planning Extension Schools. — These schools are arranged to extend over at least three days. The following courses are offered: education, agricultural organization, community program, civic improvement, farm management, town administration, public health, community recreation and homemaking. Morning, afternoon and evening sessions are held in these schools.

Educational Exhibits at Fairs and Other Shows. — The college co-operates with the managers of fairs, industrial expositions, corn shows, poultry shows, fruit shows and other exhibitions by making educational exhibits.

For outside work a large tent has been provided. In this about thirty cabinets containing educational material are arranged. A corps of lecturers and demonstrators accompany the exhibit and give practical instruction daily.

For inside work a space at least 40 by 60 feet is required for this exhibit. Smaller exhibits along special lines are sent to corn, fruit and poultry shows, milk shows, child welfare exhibits, and so forth.

The managers of fairs and exhibits are required to partially meet the cost of presenting these exhibits.

Extension Work in Special Fields.

Extension Work in Fruit Growing. — This work includes lectures and demonstrations on laying out and planting orchards, pruning, spraying, thinning, grading, packing and marketing fruits. Demonstration orchards, new and renovation plots, are established in different sections of the State, under a co-operative agreement between the college and the owners of land. Extension schools in fruit growing and fruit grading and packing are arranged on request. Visits to farms for advisory work are made, and correspondence on orcharding subjects is invited.

Extension Work in Animal Husbandry. — This work includes lectures, demonstrations and advisory assistance on subjects pertaining to cattle, horses, sheep and swine, as well as instruction in barn planning. Assistance in organizing dairy improvement associations and breeders' associations is given; stock-judging contests for boys are arranged at the leading fairs.

Extension Work in Dairying. — This includes lectures and demonstrations on the handling and care of milk, cream, butter and cheese; Babcock testing, dairy utensils and dairying manufactures. Educational campaigns may be arranged in different communities, seeking to educate producers, dealers and consumers as to the production and distribution of clean, safe milk.

Extension Work in Poultry Husbandry. — In addition to conferences at the college and visits to the plants of poultrymen, advice on general poultry management, diseases, mating, and laying out and planning buildings, this

work includes co-operative work with other State and county agricultural and educational organizations, exhibits of poultry appliances at fairs and shows and other incidental phases.

Extension Work in Farm Management, Field Studies and Demonstrations. — This is carried on co-operatively between the college and the office of farm management of the United States Department of Agriculture at Washington. It consists of a study of farm conditions and farm management problems; instruction in keeping farm accounts and growing field crops; the use of fertilizer and lime; advice as to farm equipment, buildings, and so forth.

Extension Work in Rural Civic Planning. — This is carried on in connection with the Department of Landscape Gardening at the college. Assistance is rendered in various rural and village improvement enterprises, such as the planting and care of shade and street trees, the planning of playgrounds, school grounds, cemeteries, picnic grounds, the beautifying of waterfronts, the rearrangement and development of town commons and reservations of historic interest, and similar activities. Efforts are made to co-operate with local granges, men's and women's clubs, village improvement societies and like organizations.

Junior Extension Work. — This is an organized effort to promote in the public schools of the State the study of agriculture and practical arts relating to country life. This is accomplished by means of conferences with school officials and school patrons, the promotion of agricultural clubs among the school children, and lectures before granges, farmers' clubs and other interested organizations. The work of the agricultural clubs is under the direction of the superintendent of schools or some one recommended by him. Each town should hold an annual exhibit of products. Exhibits representing rather extensive districts are incorporated with the various agricultural fairs in the State. In this manner elementary instruction in agriculture is promoted by the combined efforts of the public schools, of the patrons of the schools through their agricultural fairs, and of the Agricultural College, which in turn co-operates with the State Board and the United States Department of Agriculture.

Extension Work in Home Economics. — The Extension Service, through its home economics workers, stands ready to assist in solving problems relative to the household in the same manner as it is endeavoring through other workers to aid in working out problems of the farm. The work, among other things, includes lectures and demonstrations, assistance in forming girls' clubs and home economics clubs for women, and co-operation with existing organizations in the matter of interesting young people in the proper care of the home.

Local Community Organization. — A number of communities in the State have appealed to the college for aid in bringing the various organizations in the community to a higher state of efficiency, in order that they themselves might take definite steps toward community development and advancement. The college is now prepared to make scientific studies of communities which lead up, by means of surveys, to the organization of local committees to study the agricultural, educational, religious, transportation, recreation and civic needs of the communities. Several State organizations and some national organizations are usually brought in to aid in working out the plans presented by these committees. Conferences on community affairs are held upon request. The college acts merely in an advisory capacity, the communities themselves doing the actual organization work.

Library Extension Work. — This consists principally of loaning to public libraries of the State general collections of 10 to 30 books and bulletins on agriculture and related subjects. Special collections of smaller size on specified subjects, such as fruit growing, dairying, poultry, beekeeping, home economics, and so forth, are also sent out. These may be kept from four to eight weeks, according to the demand for them. The only expense to local libraries is transportation charge on the books both ways. The college library also supplies, upon request, information regarding books on agriculture and related subjects.

Agricultural Surveys. — To acquire definite information as to existing conditions in rural communities, to be used as a basis for further extension work, agricultural surveys are made. The different organizations and officials in the community, such as the town officers, superintendent of schools and teachers, clergymen, librarians and others, usually co-operate in making such surveys. The survey covers all phases of community life, including soil survey, farm management practices, and the educational, social, religious and recreational life. The inventory is made upon carefully prepared blanks.

Business Co-operation and Marketing. — This work has for its object the establishment of agriculture on a better business basis. Assistance is given in organization of co-operative buying and selling associations, the securing of rural credit, the adoption of better methods of marketing, the establishment of a better market for agricultural produce, and other lines of agricultural co-operation.

Demonstration Farms and Plots. — Believing that one of the most effective ways of teaching modern farm practice is by the establishment of demonstrations (not experiments) in all sections of the State, thus showing a man on his own land and under his own conditions the result of proper farm practices, the college is placing demonstration plots throughout the State, showing the proper fertilization for grass and other crops, the results of rotations, the proper care of orchards and dairy management. For several years the Faunce Demonstration Farm has been under the advisory direction of the college, as is also the Paige farm at Hardwick. The Faunce farm has proved to the Cape Cod region that small fruit, poultry and vegetables can be successfully grown there. Demonstration farms are usually managed by a committee or board of trustees representing the farm and a committee appointed from the college acting jointly.

County or District Agricultural Agents. — As rapidly as State, government and local funds are available, men trained in agriculture are being assigned to counties and districts of the State to act as agricultural agents. Residents of the county or district may, without cost, call upon the agent for assistance upon any agricultural subject. The work is being partly supported through the co-operation of the United States Department of Agriculture, the college and the community engaging the agent.

Advisory Work with Institutions and Individuals. — Special effort is made to comply with as many of the requests of State institutions and individuals who ask for advice on farm problems as possible. The force of instructors available for this work is at present insufficient to take care of all the demands. Special trips, including visits to a number of the various State institutions, are occasionally made by a group of specialists.

Publications of the Extension Service. — In addition to the regular circulars and bulletins which announce the various short courses and lines of work mentioned, publications giving timely information on agricultural

subjects are issued. Large numbers of helpful circulars and bulletins are annually distributed. A series of bulletins especially for the farm woman is one feature of this work. Reports of the work of the Extension Service, dairy record blanks, farm account blanks, boys' and girls' club circulars, lists of books, and so forth, may be had upon request.

Co-operation with Other Organizations. — The aim of the Extension Service is to co-operate with existing organizations so far as possible. It is, therefore, glad to work with local organizations, and welcomes suggestions from town officers, local granges, farmers' clubs, women's clubs, Y. M. C. A.'s, Y. W. C. A.'s, boards of trade, village improvement societies, teachers, clergymen, librarians and others interested in agriculture and country life, as to needs and methods best adapted to the meeting of these needs.

Information by Correspondence. — Besides the activities mentioned, hundreds are helped through personal visits to farms, and still larger numbers through letters of inquiry, which always receive the most careful attention from every department of the institution.

Pamphlets and bulletins are sent free to all who apply for them, and any who desire such help as has been mentioned should address the Director of the Extension Service, Massachusetts Agricultural College, Amherst, Mass.

General Information.

General Information.

A. FINANCIAL AND ADMINISTRATIVE.

Student Expenses.

Tuition.[1] — Tuition is free to residents of Massachusetts. Students who are not residents of Massachusetts are charged a tuition fee of $60 a year. The tuition charged persons not citizens of the United States is $120 a year. Students entering from Massachusetts are required to file with the president a statement signed by either town or city clerk stating that the applicant's father is a legal resident of Massachusetts; a similar statement is required of those entering from other States.

All students entering the college for the first time as undergraduates or unclassified students are charged a matriculation fee of $5, which in event of a student leaving the institution shall, if all bills due the college are paid, be remitted, or which shall upon graduation be considered as payment for the diploma.

Dormitories and Board. — The college has dormitory accommodations for about 62 students. The rooms in the dormitories are occupied by the upper classmen, hence new students find it necessary to room in private houses. The rooms in the college dormitories are unfurnished; for the most part they are arranged in suites of three, — one study room and two bedrooms. These rooms are heated by steam and lighted by electricity; they are cared for by students occupying them. The dormitory rent for each person varies from $39 to $66 a year. The rent for furnished rooms in private houses ranges from $1 to $3 a week for each occupant. Correspondence in regard to rooms should be addressed to the dean of the college.

Board may be obtained at the college dining hall. At present the price of board there is about $5 a week. Board is furnished at cost, the price being determined by adding 5 per cent. to the audited rate for the previous three months, and at the end of the period final settlement is made on the basis of actual cost.

Expenses.

The necessary college expenses are estimated as follows: —

Tuition: citizens of Massachusetts, free; other citizens of the United States, $60 a year; foreigners, $120 a year.

	Low.	High.
Matriculation fee, first year,	$5 00	$5 00
Room in college dormitories or in private houses,	39 00	110 00
Board in college dining hall, $5 a week,	180 00	180 00
Laundry, 50 to 85 cents a week,	18 00	30 00
Military uniform, first year,	17 00	17 00
Laboratory fees,	5 00	20 00
Books, stationery and miscellaneous items,	11 00	28 00
	$275 00	$390 00

[1] This statement applies to those registering as regular or unclassified students.

Other Expenses. — Prospective students should understand that the above estimates cover expenses which may be called strictly college expenses, and that there are other financial obligations voluntarily placed upon students which they should expect to meet. Chief among these are class assessments and taxes levied for maintenance of various organizations, such as the Social Union, Athletic Association, weekly publications, etc. Such expenses vary from $15 to $30 a year. Additional financial responsibility is also assumed by students joining a fraternity or entering into other social activities of the college. Students rooming in college dormitories are obliged to equip their own rooms with furniture. The college assumes no responsibility in regard to the safe keeping of student property either during the college term or vacations, except under such special arrangement as may be made with the treasurer. Besides the amount necessary for clothes and traveling, the economical student will probably spend between $300 and $425 per year.

Initial Charges.

At the opening of the college year, before students are registered in their classes, the following charges are payable at the treasurer's office: —

	Freshmen.	Sophomores.	Juniors and Seniors.
Matriculation fee,	$5 00	-	-
Board (if at college dining hall) four weeks in advance,	20 00	$20 00	$20 00
Assessment for support of Social Union,	1 00	1 00	1 00
Laboratory fees,	5 00	5 00	2 00-10 00
Military uniform,[1]	17 00	-	-
Room rent (if in college dormitory),	-	-	12 00-20 00
Student tax for support of athletics,[2]	8 00	8 00	8 00
Student tax for support of nonathletic activities,[2]	2 50	2 50	2 50

[1] This cost is subject to modification from year to year.

[2] While this is not essentially a college charge, the treasurer of the college acts as collector for the student activity, and all students are expected to make the payment as indicated. The subscription price of the "Collegian" is fixed by the managers; the amount of athletic tax by vote of the student body.

Laboratory Fees.

The principles observed in establishing laboratory fees are the requirement that students pay for those materials actually used which cannot be supplied by the individual, and that the laboratory fees include a charge sufficient to guard against wanton waste and breakage. Fees may be established for any course without previous announcement. At present, the fees charged are as follows: —

Agronomy: —	Per Semester.
Course 27, 3,	$1 50
Course 50, 1,	2 00
Course 51, 3,	2 00
Course 75, 1,	1 50
Course 76, 3,	1 50

	Per Semester.
Animal husbandry: —	
Course 1, 1 and 2,	$1 00
Course 25, 1,	1 50
Course 26, 2,	1 50
Course 50, 2,	1 50
Course 78, 2,	1 00
Dairying: —	
Course 50, 1,	2 50
Course 51, 3,	2 50
Course 75, 2,	2 00
Course 76, 3,	3 00
Course 77, 1,	2 50
Farm administration: —	
Course 75, 2,	1 50
Course 76, 3,	1 50
Poultry husbandry: —	
Course 51, 1,	2 50
Course 53, 3,	3 00
Course 55, 3,	2 50
Course 76, 1,	2 00
Course 77, 1,	2 00
Rural engineering: —	
Course 25, 1,	1 50
Course 26, 2,	1 50
Course 76, 1,	1 50
Course 77, 2,	1 50
Course 78, 3,	1 50
Floriculture: —	
Course 50, 1,	2 50
Course 51, 2,	2 50
Course 52, 3,	2 50
Course 53, 1,	2 50
Course 75, 1,	2 00
Course 76, 3,	2 00
Course 77, 2,	2 50
Course 78, 3,	2 50
Forestry: —	
Course 50, 1,	2 00
Course 51, 2,	3 00
Course 75, 1,	4 00
Landscape gardening: —	
Course 50, 1,	3 00
Course 51, 2,	3 00
Course 52, 3,	4 00
Course 76, 2,	4 00
Course 77, 3,	4 00
Course 79, 3,	2 00
Market gardening: —	
Course 50, 3,	2 00
Course 75, 1,	3 00
Course 76, 2,	3 00
Pomology: —	
Course 75, 1,	3 00
Course 76, 2,	3 00

	Per Semester.
Drawing: —	
Course 25, 1,	$3 00
Course 26, 2,	3 00
Botany: —	
Course 3, 3,	3 00
Course 25, 1,	3 00
Course 26, 2,	3 00
Course 50, 1,	3 00
Course 51, 2,	5 00
Course 52, 1,	4 00
Course 53, 2,	4 00
Course 54, 3,	4 00
Course 55, 1,	5 00
Course 56, 2,	5 00
Course 75, 1,	5 00
Course 76, 2,	5 00
Course 77, 3,	5 00
Course 78, 1,	5 00
Course 79, 3,	5 00
Course 80, 3,	5 00
Course 82, 2,	5 00
Course 83, 3,	5 00
Course 84, 2,	5 00
Course 85, 3,	5 00
Entomology: —	
Course 75, 3,	2 00
Course 76, 1,	3 00
Course 77, 2,	3 00
Course 78, 3,	3 00
Chemistry: —	
Course 1, 1,	3 00
Course 2, 2,	3 00
Course 3, 3,	3 00
Course 4, 1,	3 00
Course 5, 2,	3 00
Course 6, 3,	3 00
Course 25, 1,	4 00
Course 26, 2,	4 00
Course 27, 3,	5 00
Course 30, 3,	4 00
Course 51, 1,	5 00
Course 52, 2,	5 00
Course 60, 1,	4 00
Course 61, 2,	5 00
Course 62, 3,	5 00
Course 65, 3,	4 00
Course 76, 1,	5 00
Course 77, 2,	5 00
Course 80, 1,	5 00
Course 90, 2,	5 00
Course 91, 3,	5 00
Course 92, 2,	5 00
Course 93, 3,	5 00
Course 94, 2,	5 00
Course 95, 3,	5 00
Mathematics and engineering: —	
Course 27, 3,	2 00
Course 78, 3,	2 00

	Per Semester.
Microbiology: —	
Course 51, 2 and 3,	$5 00
Course 52, 3,	5 00
Course 75, 2,	5 00
Course 76, 3,	5 00
Course 80, 2,	5 00
Course 81, 1,	5 00
Course 82, 1,	5 00
Course 83, 1,	5 00
Physics: —	
Course 27, 3,	3 00
Course 50, 1,	3 00
Course 51, 2,	3 00
Course 52, 3,	3 00
Veterinary science: —	
Course 78, 1,	2 00
Course 79, 1,	2 00
Course 80, 3,	2 00
Course 85, 1,	2 00
Course 86, 2,	2 00
Course 87, 3,	2 00
Zoölogy and geology: —	
Course 25, 1,	3 00
Course 27, 3,	3 00
Course 50, 1,	3 00
Course 51, 2,	4 00
Course 52, 3,	4 00
Course 53, 1,	4 00
Course 54, 2,	3 00
Course 55, 3,	3 00
Course 75, 1,	3 00
Course 76, 2,	3 00
Course 77, 3,	3 00
Rural journalism: —	
Course 53, 1,	2 00
Course 54, 2,	2 00
Course 55, 3,	2 00
Course 77, 1,	2 00
Course 78, 2,	2 00
Course 79, 3,	2 00
Course 80, 1,	2 00
Course 81, 2,	2 00
Course 82, 3,	2 00
Music (each course),	3 00

Student Aid.

Self Help. — Many students are obliged to find work of some sort to earn their way through college. A few men have met their entire expenses in this manner, many more have paid a large part of their expenses, and many have earned a small proportion of the cost of their college education; but the college recommends that no new student enter without having at least $150 and preferably $250 with which to pay his way until he can establish himself in some regular work. The college does not encourage students to enter without money in the expectation of earning their way entirely. The ordinary student will

find it better either to work and accumulate money before coming to college, or to take more than four years in completing his college course, or, instead, to borrow money sufficient to carry him through. No student should undertake work that interferes with his studies, and students should understand that, owing to the large number of applications for employment, no one man can receive a large amount of work at the college. A number of students find opportunities for earning money without depending upon the college to furnish them with work.

So far as possible needy students will be employed in some department of the college. The divisions of agriculture and horticulture usually afford the most work, although there are several permanent janitorships available for students, and sixty or more students are employed at the dining hall.

Application for student labor should be made directly to Kenyon L. Butterfield, president of the college. Applicants are required to present statements from parent or guardian and from a public official or other responsible person of the town or city in which they reside, explaining the necessity of the applicant's need of assistance. Students whose deportment or class work is not satisfactory are not likely to be continued in student labor. The most desirable and responsible positions are naturally assigned to those needy students who have been in the institution longest and who have demonstrated their need and ability. Students, therefore, may find it rather difficult to obtain all the work they desire during their freshman year; as a matter of fact, however, any student who is capable of doing a variety of things, and who is a competent workman, usually finds little difficulty in obtaining all the work that he can do from the outset.

Special Notice to Needy Students. — In the last few years the demand for paid labor on the part of new students has far exceeded the amount of employment that the college can offer. The college cannot promise work to any student, particularly to freshmen; it accordingly urges prospective students who are dependent entirely upon their own efforts not to undertake the course before they have earned enough money to carry them through, or nearly through, the first year.

Student Accounts.

The following rules are enforced concerning student accounts: —

No student will be allowed to graduate until all bills due the institution from him are paid.

College charges, such as room rent, laboratory fees and tuition, must be paid in advance, at the beginning of each term. This rule is strictly adhered to, and no student will be allowed to complete his registration until such payments are made.

Every student boarding at Draper Hall is required to pay at the beginning of each term at least one month's board in advance; and no student will be allowed to continue to board at Draper Hall if at any time during the term he is more than one week in arrears in his payment for board.

All money due for student labor shall at the discretion of the treasurer of the college be applied on account toward any bills that a student may owe to the institution.

Student Relations.

The customary high standard of college men in honor, manliness, self-respect and consideration for the rights of others constitutes the standards of student deportment.

Any student known to be guilty of dishonest conduct or practice must be reported by the instructor to the president for discipline.

The privileges of the college may be withdrawn from any student at any time, if such action is deemed advisable.

It should be understood that the college, acting through its president or any administrative officer designated by him, distinctly reserves the right not only to suspend or dismiss students, but also to name conditions under which students may remain in the institution. For example, if a student is not doing creditable work he may not only be disciplined but he may also be required to meet certain prescribed conditions in respect to his studies, even though under the foregoing rules his status as a student be not affected. The same provision applies equally to the matter of absences ("cuts"). According to the rules a student is allowed a certain percentage of absences from class and other exercises. This permission, which implies a privilege and not a right, may be withdrawn at any time for any cause.

Similarly, also, it applies to participation in student activities. Though this will ordinarily be governed by the rules as already laid down, yet, if in the judgment of the college authorities a student is neglecting his work on account of these activities, the privilege of participating in them may be withdrawn for such time as is considered necessary. Moreover, it may be withdrawn as a punishment for misconduct. Prospective students or their parents may, upon application, obtain a copy of the faculty rules governing student relations to the college.

Infirmary.

The college maintains an infirmary for the care of sick or injured students. The buildings now available for this purpose are quite inadequate for the needs of the institution, and it is hoped that in the near future other buildings of this kind may be erected and the general equipment somewhat amplified. At present two small buildings, built especially for hospital purposes, are used for the infirmary.

The following statement outlines the plan followed in the management of the infirmary with respect to students: —

Management of the Infirmary.

Supervision.

1. The infirmary is under the *general supervision* of Dr. Charles E. Marshall who is designated as Supervisor of the Infirmary. Miss Florence Levensaler the resident nurse, is in *immediate* charge of the infirmary.

Use of Infirmary.

2. Students are urged to go to the infirmary at any time that they are in need of the services rendered by the resident nurse or by a town physician. Inasmuch as Professor Hicks gives special attention to all student diseases, it

is to be expected that the majority of the students will go to the infirmary at the suggestion of Professor Hicks. This understanding, however, should in no way deter students from going to the infirmary voluntarily at any time.

General Health.

3. Students are urged to consult Professor Hicks or Miss Levensaler immediately when signs of physical disorder appear. Severe attacks of cold or other forms of illness can usually be avoided if treatment is administered in the incipient stage. The purpose of the infirmary is to help maintain the general good health of the students, as well as to furnish a suitable place for professional attention in cases of severe illness or accident.

General Fee.

4. The infirmary fee will be at the rate of $1 a day, and will be charged when one or more meals are obtained at the infirmary, or when the student remains at the infirmary for one or more nights. No charge will be made for miscellaneous treatment of a minor character unless the patient receives one or more meals or remains at the infirmary for one or more nights.

Additional Expenses.

5. In addition to the fee charged, as specified in paragraph 4, the following additional expenses will be charged to the patient: —

(*a*) *Nurses.* — In case a special nurse is required for the proper care of an individual, the services and board of this nurse will be paid by the patient. Such a nurse will be under the general supervision of the resident nurse.

(*b*) *Professional Service.* — If a student requires medical attention by a physician, he will be required to select his physician and become responsible for fees charged by the physician.

(*c*) *Supplies.* — Special medical supplies prescribed by a physician or nurse will be charged to the patient. No charge will be made for ordinary medical supplies kept in stock at the infirmary and furnished students in minor cases of illness or accident.

(*d*) *Laundry.* — Expense for personal laundry incurred by students while in the infirmary will be charged to the individual student.

B. COLLEGE ACTIVITIES.

General Exercises.

Chapel exercises are held two mornings each week. On Wednesday an afternoon assembly is held, to which some prominent layman or professional man is invited to speak. The object of these assemblies is to bring to the students discussions of topics of present-day interest. A special chapel service on Sunday is usually held during the winter months. Students are required to attend these general exercises, although the president is authorized to excuse from chapel any student who may object to attendance thereon because of his religious scruples, provided his request for excuse therefrom is endorsed by his parent or guardian.

Student Activities.

A large number of student organizations furnish opportunity to students for work and leadership.

The Massachusetts Agricultural College Social Union was established about six years ago. All students become members of the union by paying a small fee. The union is designed to become the center of student interests. In North College it has a trophy room and a large lounging room for music, reading and study; in the basement of this building there is also a game room for pool and billiards. In the fall and winter months the union gives a series of entertainments, free to students and faculty.

The College Senate is composed of representatives of the junior and senior classes. This body serves as a general director of undergraduate conduct, and represents before the faculty the interests of the student body.

The Young Men's Christian Association is active both socially and religiously. Under its direction voluntary Bible classes are conducted during the winter months. A Catholic club has also been organized.

The musical organizations include an orchestra, a mandolin club and a glee club. These furnish music for college meetings, and occasionally give concerts at the college and at other places. A military band is maintained as part of the cadet corps.

A dramatic club has been organized, and each year presents a play.

The Public Speaking Council represents the students' interest in debate and oratory.

The Athletic Association represents in the college the interests of football, baseball, track, hockey and basket-ball.

A rifle club has been organized for a few years. Teams representing this club have repeatedly won the intercollegiate championship of the country, both in indoor and outdoor contests.

The college publications are the "Massachusetts Collegian," published weekly by the student body, and the "Index," published annually by the members of the junior class.

The Stockbridge Club is an organization of students especially interested in practical agriculture and horticulture. Regular meetings are addressed by outside speakers, and members present papers and engage in discussions.

Clubs also exist in the Departments of French, Entomology, Floriculture, Landscape Gardening, Zoölogy and Agriculture Economics.

There has recently been organized a Collegiate Country Life Club, the membership of which is composed of faculty and students who are particularly interested in the study of country life problems.

A nonathletics student activities board, composed of alumni, faculty and students, has charge of the finances, schedules, etc., of the musical clubs, dramatic club and student publications.

C. ACADEMIC AND DEPARTMENTAL.

Degrees.

Those who complete a four-year course receive the degree of bachelor of science. The fee for graduation from the college is $5.

Graduate students who complete the assigned courses will receive the degree of master of science upon the payment of a fee of $10. Credit may

sometimes be allowed towards this degree for teaching or other advanced work done in some department of the college.

Graduate students who complete the required three-year course of study, and present a satisfactory thesis, will be granted the degree of doctor of philosophy.

Those to whom degrees are awarded must present themselves in person at commencement to receive them. No honorary degrees are conferred.

The honorary fraternity of Phi Kappa Phi has a chapter at the agricultural college. Students are elected to membership to this fraternity on the basis of scholarship. Elections are made from the highest fifth of the senior class who have attained an average grade of at least 85 per cent. during their college course.

Prizes.

Prizes are given annually in several departments for excellence in study or for other special achievement. Prizes offered in 1914 were: —

Agriculture. — The Grinnell prizes, given by Hon. William Claflin of Boston in honor of George B. Grinnell, Esq., of New York, for excellence in theoretical and practical agriculture. Three prizes, $25, $15, $10. The contest is open to those senior students whose record on the registrar's books shows an average standing of 80 or above for the technical work taken in the Divisions of Agriculture and Horticulture during the junior and senior years. Applicants should register with the head of the Division of Agriculture before noon June 2, 1917.

Animal Husbandry. — The F. Lothrup Ames prize, given by F. Lothrup Ames, Langwater Farms, North Easton, Mass., consisting of $150 a year, offered for a period of five years, beginning 1912, to be given to the three students standing highest in the work of advanced live stock judging, and to be used in defraying their expenses incurred by participation in the students' judging contest at the National Dairy Show, Chicago.

Botany. — The Hills prizes, given by Henry F. Hills of Amherst, amount to $35 annually. Competition is open to members of the senior, junior and sophomore classes as follows: for the best herbarium, $20; for the second best herbarium, $15. No collection deemed unworthy of a prize will be considered.

General Improvement. — The Western Alumni Association prize ($25) is given to that member of the sophomore class who, during his first two years in college, has shown the greatest improvement in scholarship, character and example.

Public Speaking. — The Burnham prizes are awarded as follows: to the students delivering the best and second best declamations in the Burnham contest, $15 and $10, respectively. The preliminary contests in declamation are open, under certain restrictions, to freshmen and sophomores.

The Flint prizes are awarded as follows: to the students delivering the best and second best orations in the Flint contest, a gold medal and $20 and $15, respectively. The preliminary contests in oratory are open, under certain restrictions, to all regular students.

The prizes in debate are awarded as follows: to each of the three students ranking highest in the annual debating contest, a gold medal and $15. The preliminary contests in debate are open, under certain restrictions, to all regular students.

Equipment.

Agricultural Education. — The courses in this department are planned primarily for those who are preparing to teach. The work is carried on by means of lectures, library and demonstrations. The department has an office, lecture room and a laboratory in the Veterinary Science building. The laboratory is equipped with a balance, dishes, jars, reagent bottles, test tubes, petri dishes, lenses, a Babcock test, a Wisconsin sediment test, Bunsen burner, hot and cold water, electricity, gas and other appliances for giving demonstration and practice lessons in Secondary Agriculture. There is also equipment for conducting children's gardens on the campus. Instruction in school gardens constitutes a part of the practice work of those training for the occupation of teaching. Some practice work in teaching is done in the grammar grades of the Amherst schools, and in the agricultural departments of Hopkins' Academy, and Smith's Agricultural School at Northampton. This department is also intimately related to the matter of recommending candidates for teachers' certificates. At least four courses in the department are required of students preparing for such certificate. The office is supplied with school and college reports, also a large number of pamphlets and bulletins relating to the subject of agriculture in the schools, courses of study, etc. See note relative to teachers' certificates, under major in Agricultural Education.

Agronomy. — The work in agronomy is carried on by means of lecture, laboratory and field work. The soil laboratories are located in the basement of Stockbridge Hall, and include an elementary laboratory with locker equipment for 200 men, and desk space for four divisions of 50 men each, and an advanced soil laboratory for the work of upper classes, with locker space for 80 men. This laboratory is also equipped with balance room, centrifuge room, steam ovens and moisture cabinets. There is also a workroom attached, equipped with power for grinding soils, fodders and the like.

The crop laboratories are located on the second floor of Stockbridge Hall, the room for seed study being at the south end and allowing for sections of 50 men each. The laboratory for cereal and forage crop work is at the north end of the building, and has locker equipment for 64 men. This laboratory is equipped with large steam ovens, constant temperature electric ovens, Brown-Duval moisture apparatus and ovens for seed germination. Attached is a balance room and also a storeroom; while on the fourth floor of Stockbridge Hall is a room equipped for the storage of seed corn, grains and grasses.

Animal Husbandry. — An accurate and definite knowledge of the market types and grades, and of the various breeds of live stock, is fundamental to the work in this department. The department is equipped with an excellent laboratory, Grinnell Arena, which has a seating capacity of 180, and which is fully adapted to the requirements. There are upwards of 125 head of dairy cattle of various ages available for class-room work; among these are included superior representatives of the Jersey, Guernsey, Ayrshire and Holstein breeds. There are flocks of pure-bred Shropshire and Southdown sheep of the best breeding and individuality. Considerable numbers of pure-bred Berkshire and Yorkshire pigs are maintained. The college possesses pure-bred Percherons and French coach horses, besides many work teams of different types, which are available for class-room purposes. A set of plaster of Paris

models of individuals of foreign and domestic breeds of horses, cattle, sheep and swine, and a collection of the different foodstuffs available for the use of the New England farmer, are included in the equipment for this work. An excellent set of upward of 250 lantern slides, portraying the leading prize-winning, producing and breeding animals of the leading breeds, — horses, cattle, sheep and swine, — belongs to this department, and is regularly used in instructional work. This equipment is being added to from time to time as funds are available.

Botany. — The Department of Botany occupies Clark Hall, a brick building 55 by 95 feet, two stories high, with basement and attic. It has two lecture rooms, one seating 154 and the other seating 72 people; one seminar and herbarium room; a large laboratory for freshman and sophomore work, and one for junior and senior work; a laboratory for plant physiology, which is well supplied with apparatus for the study of simple phenomena in plant physiology, such as respiration, metabolism, transpiration, heliotropism, etc.; and three rooms specially fitted for graduate students. The experiment-station laboratories devoted to botanical research are also in this building. A small museum contains material especially useful in the teaching and illustration of plant phenomena; and on the third floor is a collection of Massachusetts timber trees, specimens showing peculiar formations of plant growth, and various specimens illustrative of scientific methods of treating trees. A conservatory 28 by 70 feet is connected with the laboratory. This is designed for experimental work and for housing material often needed for instruction.

The laboratories and lecture rooms are of modern construction, finely lighted and supplied with modern compound microscopes, dissecting microscopes, microtomes and other apparatus, and a large series of charts. In addition to a physiological laboratory the basement contains a seed and soil room, and a convenient workshop provided with benches for wood and metal work, an electric motor, a power lathe and other tools and appliances. The herbarium contains about 18,000 sheets of flowering plants and ferns, 1,200 sheets of mosses, 1,200 sheets of lichens and liverworts, and over 20,000 specimens of fungi.

Chemistry. — The college Department of Chemistry occupies the entire building previously known as the "old chapel." The basement is used for the storage of apparatus and chemicals. The first floor contains large laboratories devoted to organic, physiological and physical chemistry, and qualitative analysis. The second floor is occupied by the general lecture room, by offices for the several members of the staff and by laboratories for analytical chemistry. The third floor has been fitted for work in general chemistry, and has desk room and hoods sufficient to accommodate 66 students at one time. Each place is supplied with reagents and apparatus for independent work. This floor is also occupied by a lecture room that will seat 100 students.

The entire laboratory is well equipped with the necessary apparatus and chemicals for all students who desire to perfect themselves as expert chemists, or who wish to study chemistry as a supplement to some other line of practical or scientific work. The equipment includes a valuable and growing collection of specimens and samples of minerals, soils, raw and manufactured fertilizers, foods, milk products, fibers, various other vegetable and animal products and artificial preparations of mineral and organic compounds; and also a series of preparations for illustrating the various stages of different manufactures from raw material to finished product.

Dairying. — The dairy work is given in Flint Laboratory, a new building designed for the dairy department. It contains large, well-lighted, sanitary and well-equipped laboratories. The equipment is new and of the best types of market milk and farm dairy machines.

Dining Hall. — Draper Hall, a brick colonial building equipped with the modern conveniences of a dining hall, was opened in 1903. The dining service is under the supervision of the college. The building contains a limited number of rooms for young women students.

Drawing. — The class in drawing occupies a room on the second floor of Wilder Hall. It is equipped with tables and adjustable drawing stands. The necessary materials and implements are provided. The equipment includes drawing models, and plaster casts of leaves, flowers, fruits, human and architectural details and garden ornaments, two universal drafting machines, an eidograph, centrolineads, a set of ship splines and French curves, complete water-color outfits, automatic crosshatchers and protractors.

Entomology. — *General Entomological Laboratories.* — The equipment for work in entomology is perhaps unexcelled in this country. In the new fireproof entomological and zoölogical building, first used in the fall of 1910, are fine lecture rooms, laboratories and museums for use in the different courses. The senior laboratory will accommodate 70 students at one time; a desk, equipped with compound microscope and accessories, together with glassware, reagents, etc., and supplied with electric light and gas, is provided for each student. Dissecting microscopes, microtomes and other apparatus are available for use. The graduate laboratory is similarly equipped, and it will accommodate 20 students. The large and rapidly growing collections of insects are in a room adjoining both laboratories. In the library of the building is an excellent collection of the more important books and journals treating of entomology, and many more are accessible in the college library and in the private libraries of the professors, in all making available more than 25,000 volumes, many of which cannot be found elsewhere in the United States. A card catalogue giving references to the published articles on different insects contains more than 60,000 cards, and is the largest index of its kind in the United States, and probably in the world. In the basement is a pump room where may be studied the construction of the different types of spray pump and methods of repairing them; hose, couplings, nozzles and the other parts of spraying outfits are provided, not only for examination but for use. In another room chemical desks and apparatus provide opportunities for the determination of the impurities and adulterations of insecticides. As the insectary of the Massachusetts Agricultural Experiment Station is in the same building the facilities it offers are also available. A greenhouse, where plants infested with injurious insects are under observation and experimental treatment, is also open to students. Photographic rooms with cameras and other photographic apparatus are provided, and the large greenhouses, gardens, orchards and grounds of the college offer further opportunities for the study of injurious insects under natural conditions.

Entomology. — *Beekeeping.* — For this work the main office, museum and lecture rooms are in the entomological building. There is also an apiary covering approximately two acres which will consist of about fifty colonies of bees in various types of hives and maintained for the several practical and experimental purposes. The apiary also includes a collection of nectar-yielding plants representative of the native flora as well as of the more impor-

tant nectar sources from other localities. Especial opportunity is therefore given for a study of this fundamental problem of forage. Upon the apiary site is an eight-room building (the first in the world erected exclusively for teaching beekeeping) modeled to meet both the requirements of teaching and of a practical apiary. This building contains a boiler room, capacious wintering cellar, wax extraction room, general carpenter and work shop, laboratory, office, honey extraction room and stock room. The beekeeping equipment also includes an unexcelled collection of apicultural implements, natural history specimens and other curiosities. Practically every device used in American apiculture is available, it being the aim of the department to procure new inventions and implements as fast as they appear for the purpose of study and comparison. Available to the students is a private library of apicultural literature consisting of upwards of 900 volumes and papers, possibly the most complete collection in the country. This entire equipment is acknowledged unique in model and in completeness for the United States and for the world.

Farm Administration. — The college farm of 250 acres is under the general supervision of the Department of Farm Administration, and furnishes demonstration material. It includes improved land, pasture land and a farm wood lot. The improved land illustrates the value of good culture and the best known methods for the maintenance of fertility. The farm is equipped with suitable buildings and good machinery for the work carried on, of which the production of certified milk is an important branch. Several good farms in the vicinity, illustrating types of both special and general agriculture, may be inspected and studied. The offices of the department are in Stockbridge Hall.

Floriculture. — The Department of Floriculture aims to give the student a thorough knowledge of all phases in greenhouse design and construction and greenhouse heating, and in the culture of florists' crops. It is intended to train men for commercial floriculture and for the management of conservatories on private estates and parks and in cemeteries. The course is outlined to combine theoretical, technical and practical work in the most comprehensive manner possible. Probably no agricultural college has a Department of Floriculture better equipped than this. There has been erected a durable, practical, commercial range, composed of palm, fern, orchid, violet, carnation, rose and students' houses. French Hall, with its large laboratories, class rooms and offices, furnishes excellent facilities for the purposes of instruction. Besides the new glass houses, there are older houses suitable for growing bedding plants and chrysanthemums, and frames for the growing of annual and herbaceous perennial plants, violets and pansies. Many excellent specimens of trees and shrubs are growing on the college grounds, furnishing valuable material for the study of plant materials.

Forestry. — The Department of Forestry has an unusually complete equipment of the various instruments used in forest mensuration, forest mapping and engineering, timber estimating, log scaling, board measuring, etc.; a large assortment of boards illustrative of the various commercial woods found in the lumber markets. The State Forest Nursery, comprising 6 acres of land and containing, approximately, 5,000,000 trees, transplants and seedlings, is located on the college farm. Extensive forests containing every variety of tree common to New England are within walking distances of the college. The college campus affords an arboretum containing an ex-

ceptionally large number of trees not native to New England. The library contains complete sets of government bulletins, circulars, State reports and all the best books on forestry subjects. The recent designation of Mt. Toby as a forest reservation provides more than 700 acres of forest, representing nearly every forest growth within the State.

Geology. — A large, well-lighted laboratory for geology, 27 by 50 feet, is in the basement of the new building for entomology, zoölogy and geology. This is equipped with cabinets, models, charts and a teaching collection of rocks. It has a seating capacity of 50 persons. Adjoining this is a smaller laboratory, 21 by 27 feet, for mineralogy, supplied with gas and cabinets for models, crystals and minerals. There is also a small laboratory for grinding thin sections, and a private laboratory, 6 by 19 feet, for analysis work. The geological museum is 27 by 48 feet. It has six large cases for exhibition purposes. The equipment for geology is being enlarged. At present, in addition to the general items mentioned above, it consists of a petrographic microscope, an illustrative series of thin sections, a small collection of invertebrate fossils, some casts of vertebrate fossils, a collection of the building stones of Massachusetts, and a duplicate set of the Edward Hitchcock survey collection of the rocks and minerals of Massachusetts.

Heating, Lighting and Power. — The college supplies its own light, heat and power, including electricity for the night lighting of the campus and its approaches. The machinery of the barn, the dairy and other buildings is operated by electricity generated at the power-house. The college has also a machine shop and well-equipped carpenter shop.

Landscape Gardening. — The work in landscape gardening is developed in a strong technical four-year course; the first two years are occupied with required studies, including botany, horticulture, surveying and mathematics, and the last two years are devoted to more specialized studies in landscape gardening, arboriculture, floriculture, entomology, botany and mathematics. The environment is unusually favorable. The strictly technical work in landscape gardening is taught in light and comfortable drafting rooms, fully furnished with instruments and accessories for thorough work. There is a well-selected library, and the equipment of surveying and drafting instruments is unusually complete and practical.

Library. — The library — stack room, reading room and office — occupies the entire lower floor of the Chapel-library building. It contains about 53,000 volumes and a large number of bulletins, farm papers and other material, which is being put into good working order as fast as possible. Works on agriculture, horticulture, botany, entomology and the various sciences predominate, but literature, history and sociology are well represented and receive due attention. The reading room provides a good variety of popular and technical periodical literature, encyclopedias and general reference books.

The library is being reclassified and recatalogued in order to make the splendid material accessible and of the greatest working value. Every effort is being made toward developing the college library into a vital intellectual center, of equal value to every student, teacher and teaching department on the college campus. Consequently only the most cordial relations are cherished, and the fewest and most imperative rules concerning the circulation of books and deportment are enforced. An agricultural reference library is maintained in Stockbridge Hall, and department libraries are also maintained in some of the other buildings on the campus.

Occasional lectures are given to regular and short-course students in order to make the best use of the library equipment. Emphasis is laid upon the card catalogue, periodical indexes, bibliographies and guides, and the large collections of United States Department of Agriculture and experiment station literature.

Library hours are from 7.30 A.M. to 9.30 P.M. every week day except Monday and Friday mornings, when the library is open at 8 o'clock, and from 9 A.M. to 1.30 P.M. on Sundays in term time. Shorter hours prevail during vacation.

MARKET GARDENING. — The purpose of the courses in market gardening is to acquaint the student with the theories and practice of market gardening so that he will be able to carry on the business intelligently. The equipment available for practical work consists of 10 acres of good gardening land; a large collection of horse and hand garden tools; hot-beds and cold-frames; and lettuce, cucumber and tomato houses. The students therefore have opportunity both to study and to practice the important branches of the business. Classes are taught in French Hall, a new building fitted with class rooms and laboratory particularly equipped for market gardening. A good library of works on vegetable gardening is available.

MATHEMATICS AND CIVIL ENGINEERING. — *Surveying.* — The department has a considerable number of the usual surveying instruments, with the use of which the students are required to become familiar by doing field work. Among the larger instruments are 2 plain compasses, a railroad compass with telescope, a surveyor's transit, 3 engineer's transits with vertical arc and level, a Brandis solar transit, a solar compass, an omnimeter with verniers reading to 10 seconds, adapted to geodetic work, a Queen plane table, 3 wye levels, 2 dumpy levels, a builder's level, a sextant, a hand level, and a large assortment of leveling rods, flag poles, chains, tapes, etc. For drafting, a vernier protractor, a pantograph, a parallel rule, etc., are available. The department also has a Fairbanks cement testing outfit.

MICROBIOLOGY. — The department now occupies a newly erected building and has at command laboratories, research rooms, offices and class-rooms, of thoroughly modern completeness.

MILITARY SCIENCE. — This department makes use of the campus for battalion drill, and has a special building in which there is a drill room 60 by 135 feet, an armory, an office for the commandant, a field-gun and gallery practice room and a large bathroom. The national government supplies Krag-Jorgensen rifles, with complete equipments and ammunition. The State supplies instruments for the college band. Students are held responsible for all articles of public property in their possession. The college owns an excellent target range for rifle practice, lying a short distance out of the village.

PHYSICAL EDUCATION. — The gymnasium and armory has a floor space of 5,000 square feet, and is 30 feet high, well lighted and ventilated. The main floor is used for basket ball, indoor baseball and hand ball. The gallery has been fitted up as a special exercise and gymnastic room, and is equipped with modern developing apparatus, including parallel bars, horses, bucks, chest weights, dumb-bells, Indian clubs and striking bags. An outdoor board track enables students to secure track practice through the winter, and two ice hockey rinks give ample opportunity for hockey practice. Credit is given to all students taking part in outdoor activities. "Treks" are held twice a week, and whenever possible snowshoe and skiing hikes are also held. Steel lockers and bathrooms have been installed in North and South colleges, and

the gymnasium has been fitted with a shower-room. The gymnasium classes are held the last two hours in the morning and the last two hours in the afternoon, but students may use the gymnasium at other times for exercise purposes by arrangement with the department. The regulation costume for class exercise consists of a white track suit and white rubber-sole shoes.

Physics. — Among the apparatus in use for instruction in general physics are a set of United States standard weights and measures, precision balances, a spherometer, vernier calipers, a projection lantern, etc.; in mechanics, a seconds clock, systems of pulleys and levers, and apparatus to illustrate the laws of falling bodies and motion on an inclined plane, and the phenomena connected with the mechanics of liquids and gases. The department is equipped with the usual apparatus for lecture illustration in heat, light and sound; in electricity, the equipment consists of apparatus for both lecture illustration and laboratory work, including a full set of Weston ammeters and volt meters, a Carhart-Clark standard cell, a Mascart quadrant electrometer, a Siemens electro-dynamometer, and reflecting galvanometers and Wheatstone bridges for ordinary determinations of currents and resistances.

Pomology. — The Department of Pomology has 45 acres of orchard, including apple, pear, peach, plum, cherry and quince trees. Of particular interest is the large collection of these fruits on the various dwarf stocks, showing many types of training. The recent revival of interest in dwarf fruits makes these dwarf orchards of especial value to students. There are also two commercial vineyards, and a smaller one in which are shown the principal types of trellis and the leading methods of training grapes. Several acres are used in growing the various kinds of small fruits, such as strawberries, raspberries, blackberries, currants and gooseberries. There are also nurseries, where all of these various types of fruits are grown, in which students may see them in all stages of development.

The department has a good equipment of orchard and nursery tools of all the principal types, the use of which enables students to learn the value of each type. For other orchard operations, such as spraying and pruning, the most approved makes of pumps, nozzles, pruning saws, knives, etc., are provided. For laboratory work in systematic pomology there is a collection of more than 100 wax models of apples, plums, pears and peaches, in natural colors, which are particularly valuable in identifying varieties of these fruits unknown to the student. The laboratory is also furnished with a large number of reference books on pomology; and fruit in a fresh condition is available in great variety, not only from the college orchards but from other parts of Massachusetts and from many other States. In 1912–13, for instance, apples for class use were received from Idaho, Missouri, Utah, Washington, Maine, Connecticut, Pennsylvania, Montana, Minnesota, Nebraska, Kentucky, Iowa, Wisconsin, Michigan, New York, Kansas, Colorado, Oregon, New Jersey and Vermont, besides collections of grapes from California and citrus fruit from Florida and Texas. From the college fruit plantations the following fruits were available: grapes, fifty varieties, representing three native American species and several hybrids; twenty varieties of peaches, twenty varieties of pears, twenty-five varieties of plums, eighty varieties of apples.

Poultry Husbandry. — The poultry plant consists of about 9 acres of land sloping gently to the west. The soil is a fine, rich, sandy loam, well

drained. At present the buildings consist of an incubator cellar, 22 by 34 feet, with a capacity of 4,000 eggs, over which is a demonstration building; a pipe brood house (open-pipe system), 14 by 72 feet, which will accommodate 1,200 chickens; a long laying house, 14 by 180 feet, which accommodates 500 layers and furnishes facilities for student work in pen management; a laboratory, 14 by 80 feet, for killing, picking, dressing, crate fattening, cramming, etc.; a storage building, 28 by 42 feet, for experimental incubation, poultry carpentry, poultry mechanics and storage; an experimental breeding house, 18 by 60 feet; a combination laying, testing and breeding house, 18 by 72, for experimental purposes, and a model laying house, 18 by 30, for 100 hens; the 6 old experiment-station buildings, each 12 by 18 feet, to be used as breeding houses; 14 colony houses; 8 growing crops; a manure shed, 14 by 18 feet; and an oil house, 10 by 12 feet. Instruction in this department is given in the form of lectures, demonstrations and practical work. The practical work consists of poultry carpentry, caponizing, killing, picking, dressing, packing and selling poultry; pen management and fattening; running incubators and brooders, etc. At present the stock consists of 20 leading varieties of poultry. The aim of the department is to keep good specimens of all the most popular varieties of chickens, ducks and geese, so that a thorough course in poultry judging may be given, and that visitors may find the inspection of our stock an education in itself.

Public Speaking. — In connection with the work in public speaking, three regular contests are held during the year. The Burnham contest in declamation is open to freshmen and sophomores; the Flint contest in oratory and the annual debating contest are open (under restrictions) to all regular students. These contests offer a very practical and necessary experience to all students interested in improving themselves in the art of public speaking. Prizes are given for excellence in the contests. Intercollegiate contests are arranged by the Public Speaking Council. One credit is given, except to freshmen, for a year of work in the College Debating Club.

Rural Engineering. — This department has an office and the use of a lecture room in Stockbridge Hall. The work on farm structures is given in the large drawing room in the same building. This room is fitted with thirty drawing tables. Models and blue prints are available for the study of farm buildings. A set of post molds and a machine for making cement tile afford opportunity for practical work with cement.

The rural engineering shop building is a one-story structure 68 by 126 feet. The carpenter shop in this building is fitted with benches fully equipped with tools for each student. A saw table is available for getting out material. The general repair shop is equipped with forges, benches, a drill press and grinders. The laboratory for farm machinery and farm motors is equipped with a complete line of field machines, gasoline engines and pumps. A small dynamo and switchboard are used in the study of farm-lighting systems.

The work on the small field machines is given in the basement of Stockbridge Hall, and the work on steam engines and steam heating is given in Flint Laboratory.

Rural Journalism. — The news-room, or laboratory, for the courses in rural journalism, is equipped with typewriting machines, copy tables, representative newspapers, reviews, agricultural papers, and trade journals concerning journalism and writing, selected books on journalism, reference books,

and a considerable "morgue" of indexed pamphlets, monographs and clippings on farming, rural life and rural industry, contemporary events, etc. (loan collection). The news-room and offices are in the recently completed Stockbridge Hall, near the division library of the Division of Agriculture.

Veterinary Science. — The Department of Veterinary Science occupies a modern laboratory and hospital stable, built in accordance with the latest principles of sanitation. Every precaution has been taken in the arrangement of details to prevent the spread of disease, and to provide for effective heating, lighting, ventilation and disinfection.

The main building contains a large working laboratory for student use, and several small private laboratories for special work. There is a lecture hall, a museum, a demonstration room, a photographing room and a workshop. The hospital stable contains a pharmacy, an operating hall, a post-mortem and dissecting room, a poultry section, a section for cats and dogs, and 6 sections, separated from each other, for horses, cattle, sheep and swine. The laboratory equipment consists of a dissectible Auzoux model of the horse and Auzoux models of the foot and the leg, showing the anatomy and the diseases of every part. The laboratories also have modern, high-power microscopes, microtomes, incubators and sterilizers, for work in every department of veterinary science including pathology, serology and parasitology. There are skeletons of the horse, the cow, the sheep, the dog and the pig, and a growing collection of anatomical and pathological specimens. The lecture room is provided with numerous maps, charts and diagrams.

Zoölogy. — The college offers increased facilities for the study of zoölogy. In the new building for entomology, zoölogy and geology are spacious laboratories for both undergraduate and graduate work. On the first floor is a large sophomore laboratory, 27 by 100 feet, with a present seating capacity of 100 persons. Adjoining this is a smaller room, 20 by 27 feet, for junior and senior courses. All laboratories are equipped with gas. The equipment consists of 80 compound microscopes and accessories, 70 dissecting microscopes, microtomes and accessories, paraffine baths, incubator, dissecting instruments, glassware and other necessary apparatus.

The large amphitheater lecture hall is used jointly by the Departments of Entomology and Zoölogy-Geology. It is equipped with charts and models. The zoölogical museum is drawn upon at all times for illustrative material. The zoölogical museum is 27 by 48 feet. The main room is on the first floor of the building. Above this, on a level with the second floor, is a large gallery. On the main floor are 8 large wall cases and 5 large floor cases for exhibition purposes. The gallery has 1 large wall case and 3 floor cases with space for 9 additional cases. The zoölogical collection consists of nearly 12,000 specimens. All the chief phyla are represented. Adjoining the museum is a preparator's room for the curator. The museum is open to the public from 1 to 5 p.m. on Saturdays, and on other week days from 3 to 6 p.m. The curator is Associate Professor Gordon.

List of Awards and Prizes, 1916.

Grinnell Prizes. — The Grinnell prizes, given by the Hon. William Claflin of Boston in honor of George B. Grinnell, Esq., of New York, to those members of the senior class who pass the best, second best and third best examinations,

oral and written, in theoretical and practical agriculture, were awarded as follows: —

First prize, $25, awarded to Harold Augustus Mostrom.

Second prize, $15, awarded to Ralph Fred Taber.

Third prize, $10, awarded to Raymond Alson Mooney.

General Improvement. — The Western Alumni Association prize, given to that member of the sophomore class who, during the first two years in college, has shown the greatest improvement in scholarship, character and example, $25. Awarded to Ralph Walter Hurlburt, 1918.

Hills Botanical Prizes. — Hills prizes for the best and second best herbarium, competition open to members of the senior, junior and sophomore classes, were awarded as follows: —

First prize of $20 to Roger Francis Clapp of the sophomore class.

Second prize of $15 to Carlton McIntyre Stearns of the junior class.

Public Speaking. — The Burnham prizes were awarded to the students delivering the best and second best declarations, as follows: —

First prize, $15, awarded to Henry John Burt, 1919.

Second prize, $10, awarded to Fred Bucknam Sampson, 1918.

The Flint prizes were awarded to the students delivering the best and second best orations, as follows: —

First prize, $20, awarded to Theodore Henry Reumann, 1918.

Second prize, $15, awarded to Lincoln David Kelsey, 1917.

Interclass Debate. — Won by the Freshman Debating Team, composed of Robert Burleigh Collins, James Joseph Window and Henry John Burt, — silver cup to each.

College Prize Debate. — Lincoln David Kelsey, 1917, Henry John Burt, 1919, and Thomas Lincoln Harrocks, 1916, — $15 to each.

Military Honors. — The following-named cadet officers have been granted the military diploma, and have been reported to the Adjutant-General of the United States army and to the Adjutant-General of the Commonwealth of Massachusetts as being efficient in military science and tactics and graduating therein with highest honors: —

Cadet Col. Charles Edward Hathaway, Jr.
Cadet Maj. Albert James Hicks.
Cadet Maj. Charles Albert Huntington, Jr.
Cadet Capt. Harold Aiken.
Cadet Capt. Emilio Joseph Cardarelli.
Cadet Capt. George Newlon Danforth.
Cadet Capt. Frank Eugene Haskell.
Cadet Capt. Stanley Marshall Prouty.
Cadet Capt. Everett Stackpole Richards.
Cadet Capt. Dean Albert Ricker.
Cadet Capt. Benjamin Charles Louis Sander.
Cadet Capt. Raymond Scott Wetherbee.

Rural Drama Prize. — A prize of $50 was offered jointly by Prof. E. L. Morgan and the Dramatic Society for the best rural drama produced by a member of the undergraduate student body. Awarded to Mr. Thomas Carlton Upham of the class of 1916.

Secretaries of Alumni Associations.

Associate Alumni of the Massachusetts Agricultural College.
Secretary: Dr. Charles A. Peters, 1897, Amherst, Mass.
Alumni Secretaries' Association of the Massachusetts Agricultural College.
Secretary: Ralph J. Watts, 1907, Amherst, Mass.
Alumni Club of Massachusetts.
Secretary: Edward C. Edwards, 1914, 50 State Street, Boston, Mass.
Connecticut Valley Association of the Massachusetts Agricultural College.
Secretary: Robert S. Fay, 1913, Monson, Mass.
Massachusetts Agricultural College Club of New York.
Secretary: Dr. John Ashburton Cutter, 1882, 266 West Seventy-seventh Street, New York City.
Massachusetts Agricultural College Club of Washington, D. C.
Secretary: G. A. Billings, U. S. D. A., Office of Farm Management, Washington, D. C.
Western Alumni Association of the Massachusetts Agricultural College.
Secretary: Charles A. Tirrell, 1906, 815 Steinway Hall, Chicago, Ill.
Massachusetts Agricultural College Pacific Coast Alumni Association.
Secretary: Thomas F. Hunt, 1905, Berkeley, Cal.
Massachusetts Agricultural College Club of Hawaii.
President: Allen M. Nowell, 1897, Honolulu, T. H.
Massachusetts Agricultural College Club of Worcester County.
Secretary: Charles H. White, 1909, 11 Foster Street, Worcester, Mass.
Massachusetts Agricultural College Club of Marlborough.
Secretary: William L. Howe, 1908, Marlborough, Mass.
Massachusetts Agricultural College Club of Connecticut.
Secretary: Herbert J. Baker, 1911, Storrs, Conn.

Class Secretaries.

Class of —	Secretary.	Secretary's Address.
1871	E. E. Thompson,	5 Jacques Avenue, Worcester, Mass.
1872	F. E. Kimball,	17 Harvard Street, Worcester, Mass.
1873	C. Wellington,	Amherst, Mass.
1874	D. G. Hitchcock,	Warren, Mass.
1875	P. M. Harwood,	Room 136, State House, Boston, Mass.
1876	C. Fred Deuel,	Amherst, Mass.
1877	Atherton Clark,	231 Waverley Avenue, Newton, Mass.
1878	C. O. Lovell,	201 Darke Block, Regina, Saskatchewan, Can.
1879	R. W. Swan,	41 Pleasant Street, Worcester, Mass.
1880	Alvan L. Fowler,	413 Federal Building, Philadelphia, Pa.
1881	J. L. Hills,	59 North Prospect Street, Burlington, Vt.
1882	G. D. Howe,	38 Whittier Avenue, Springfield, Mass.
1883	J. B. Lindsey,	Amherst, Mass.
1884	E. A. Jones,	New Canaan, Conn.
1885	E. W. Allen,	1923 Biltmore Street, Washington, D. C.
1886	Winfield Ayres,	616 Madison Avenue, New York City.

Class Secretaries — Concluded.

Class of —	Secretary.	Secretary's Address.
1887	F. H. Fowler, . .	Shirley, Mass.
1888	H. C. Bliss, . .	14 Mechanic Street, Attleboro, Mass.
1889	F. W. Davis, . .	85 Colberg Avenue, Roslindale, Mass.
1890	David Barry, . .	398 Walnut Street, Newtonville, Mass.
1891	H. T. Shores, . .	177 Elm Street, Northampton, Mass.
1892	H. M. Thomson, .	Amherst, Mass.
1893	F. A. Smith, . .	Hathorne, Mass.
1894	S. F. Howard, . .	Northfield, Vt.
1895	E. A. White, . .	Ithaca, N. Y.
1896	A. S. Kinney, . .	South Hadley, Mass.
1897	C. A. Peters, . .	Amherst, Mass.
1898	W. S. Fisher, . .	Peace Street Grammar School, Providence, R.I.
1899	Herbert W. Dana, .	9 Oliver Street, Salem, Mass.
1900	E. K. Atkins, . .	15 Hubbard Avenue, Northampton, Mass.
1901	J. H. Chickering, .	Dover, Mass.
1902	H. L. Knight, . .	1420 Buchanan Street, Washington, D. C.
1903	G. D. Jones, . .	North Amherst, Mass.
1904	P. F. Staples, . .	East Holliston, Mass.
1905	A. D. Taylor, . .	1900 Euclid Avenue, Cleveland, Ohio.
1906	Richard Wellington, .	2314 Scudder Street, St. Paul, Minn.
1907	Clinton King, . .	31 Elm Street, Springfield, Mass.
1908	S. J. Wright, . .	39 Wall Street, Norwalk, Conn.
1909	O. B. Briggs, . .	1011 Fidelity Building, Baltimore, Md.
1910	F. L. Thomas, . .	Auburn, Ala.
1911	L. M. Johnson, . .	Newtown, Conn.
1912	F. S. Madison, . .	East Greenwich, R. I.
1913	B. W. Ellis, . .	575 Main Street, South Weymouth, Mass.
1914	L. Ernest Smith, .	Pittsford, Vt.
1915	P. F. Whitmore, .	Sunderland, Mass.
1916	Perez Simmons, .	34 Boylston Street, Pittsfield, Mass.

Degrees Conferred and Roll of Students.

Degrees Conferred — 1916.

Doctor of Philosophy (Ph.D.).

Chapman, George Henry, Amherst, Mass., Massachusetts Agricultural College, M.Sc.
Itano, Arao, Okayamakan, Japan, Michigan Agricultural College, B.Sc.
Ruprecht, Rudolph W., Flatbush, N. Y., Massachusetts Agricultural College, M.Sc.

Master of Science (M.Sc.).

Armstrong, Robert Pierson, Rutherford, N. J., Massachusetts Agricultural College, B.Sc.
Beals, Carlos Loring, Sunderland, Mass., Massachusetts Agricultural College, B.Sc.
Lund, Russell Fort, Amherst, Mass., St. Lawrence University, A.B.
Serex, Paul, Jr., Bloomfield, N. J., Massachusetts Agricultural College, B.Sc.
Thurston, Arthur Searle, Everett, Mass., Massachusetts Agricultural College, B.Sc.

Bachelor of Science (B.Sc.).

Aiken, Harold,	Millis.
Anderson, Frank Albert,	Somerville.
Andrews, Francis Marshall, Jr.,	Manchester.
Barnes, Dwight Fletcher,	Bedford.
Barnes, Fred Leslie Walker,	Plymouth.
Bishop, Herbert Walker,	Doylestown, Pa.
Blanpied, Nelson Uhler,	Framingham.
Boyer, Edward Everett Hale,	Lynn.
Brazil, William Henry,	Leominster.
Caldwell, Harold Nute,	Lowell.
Cardarelli, Emilio Joseph,	Boston.
Chase, Esther Helen,	Holden.
Chisholm, Raymond Lincoln,	Melrose Highlands.
Clapp, Raymond Luckey,	Northfield.
Clark, Saxon Dickinson,	Springfield.
Coe, Alfred Lynn,	Fayetteville, N. Y.
Coleman, Albert Sumner,	Mendon.
Coley, William Stanton,	Wilton, Conn.
Courchene, Alcide Telesphor,	North Adams.
Curran, Harry Ambrose,	Marlborough.
Danforth, George Newlon,	Foxcroft, Me.
Darling, Homer Chester,	Mendon.
Davis, Frank Leslie,	Milford.
Dickinson, William Cowls,	North Amherst.
Dodge, Walter Eugene,	Geneva, Ohio.
Eldredge, Raymond Chase,	North Abington.
Estes, Ralph Cary,	South Framingham.
Fernald, Charles Henry, 2d,	Amherst.
Fielding, Lester Edward,	Malden.
Gaventa, Harry Reymer,	Swedesboro, N. J.
Gilmore, Benjamin Anthony,	Acushnet.
Gioiosa, Alfred Anthony,	Dorchester.
Glover, Theodore Whitford,	South Duxbury.
Goodwin, Clinton Foster,	Haverhill.
Googins, Burton,	Jersey City, N. J.
Gould, Charles Holt,	Hubbardston.
Gunn, Carlton Merrick,	Sunderland.
Hager, Clayton Marden,	Somerville.

Hall, Stanley William,	Saxonville.
Harris, William Lombard, Jr.,	Deerfield.
Harrocks, Thomas Lincoln,	Westminster.
Hart, Reginald,	Montague City.
Haskell, Frank Eugene,	Northborough.
Hathaway, Charles Edward, Jr.,	Somerset.
Hemenway, Justin Stanley,	Williamsburg.
Hendry, Arthur Ekman,	Milton.
Hicks, Albert James,	Amherst.
Holden, Mae Faustina,	Royalston.
Huntington, Charles Albert, Jr.,	Poquonock, Conn.
Jerome, Fred William,	Stockbridge.
Jones, Linus Hale,	Milford.
Jordan, Perley Balch,	Topsfield.
Kelly, Harold Russell,	Haverhill.
Kilbon, Ralph Gillette,	Springfield.
King, Edward Lee,	Norwood.
Knapton, Guy Lord,	Lawrence.
Laird, Kenneth Bradford,	Brockton.
Lieber, Conrad Hugo,	Jamaica Plain.
Lindquist, Albert Evert,	Roxbury.
Little, Harold Greenleaf,	Newburyport.
Locke, Wilbur Trow,	Lawrence.
Mahan, Harold Butterworth,	Manchester, N. H.
Mattoon, Harold Gleason,	Pittsfield.
Mooney, Raymond Alson,	Plattsburgh, N. Y.
Moses, Charles Wicker,	Ticonderoga, N. Y.
Mostrom, Harold Augustus,	North Middleborough.
Murphy, John William,	Beverly.
Nash, Clayton Wells,	South Weymouth.
Nicholson, James Thomas,	Leominster.
Palmer, George Bradford,	Brookline.
Perry, Edgar Adams,	Attleboro.
Plaisted, Philip Asbury,	Arlington.
Potter, David,	Concord.
Prouty, Stanley Marshall,	North Brookfield.
Ray, George Burrill,	Hingham.
Rich, Gilbert Warren,	Hingham.
Richards, Everett Stackpole,	Hatfield.
Ricker, Dean Albert,	Worcester.
Rogers, Tyler Stewart,	Framingham.
Rowe, Louis Victor,	Melrose.
Russell, Ernest Samuel,	South Hadley.
Ryan, William Edward, Jr.,	Stoughton.
Sander, Benjamin Charles Louis,	Cambridge.
Sanderson, Everett Shovelton,	Centreville, R. I.
Scheufele, Frank Joseph,	South Natick.
Schlotterbeck, Lewis,	Roxbury Station, Conn.
Simmons, Perez,	Pittsfield.
Stearns, Frederick Campbell,	Waltham.
Strauss, Abraham,	Roxbury.
Swan, Durelle,	Dorchester.
Taber, Ralph Fred,	Cooperstown, N. Y.
Taft, Richard Craig,	Oxford.
Topham, Alfred,	Lawrence.
Upham, Thomas Carlton,	Fitchburg.
Verbeck, Howard Graves,	Malden.
Walkden, Herbert Halden,	Westford.
Walker, Henry Marshall,	Brookline.
Wentworth, Everett Lawrence,	East Dover, Vt.
Wetherbee, Raymond Scott,	Waltham.
Whitney, Leon Fradley,	Brooklyn, N. Y.
Wildon, Carrick Earl,	Melrose Highlands.
Woolley, Harold Curtis,	Malden.

Roll of Students.

Graduate Students.[1]

Alden, Charles H., ... Amherst.
B.Sc., Massachusetts Agricultural College.

Armstrong, Robert Pierson, ... Rutherford, N. J.
B.Sc., Massachusetts Agricultural College.
M.Sc., Massachusetts Agricultural College.

Avery, Roy Crowdy, ... New York City.
B.Sc., Connecticut Agricultural College.

Bain, E. S., ... Martinsville, Ind.
B.S.Ag., Purdue University.

Bales, Harold C., ... South Deerfield.
A.B., Dartmouth College.

Beebe, Paul, ... Ithaca, Mich.
A.B., Albion College.

Bemis, Willard G., ... North Brookfield.
B. Sc., Massachusetts Agricultural College.

Bourne, Arthur Israel, ... Amherst.
A.B., Dartmouth College.

Bronson, Wesley Hotchkiss, ... Amherst.
B.Sc., New York State College of Agriculture.

Caruthers, John T., ... Nashville, Tenn.
B.Sc., Massachusetts Agricultural College.

Chapin, Edward Albert, ... Springfield.
Ph.B., Sheffield Scientific School.

Clapp, Raymond K., ... Easthampton.
B.Sc., Massachusetts Agricultural College.

Cobb, J. Stanley, ... Groton, N. Y.
B.Sc., Cornell University.

DeVault, Samuel Henry, ... Jonesboro, Tenn.
A.B., Caron Newnan College.
A.M., University of North Carolina.

Dickinson, William Cowls, ... Amherst.
B.Sc., Massachusetts Agricultural College.

Doran, William Leonard, ... North Dartmouth.
B.Sc., Massachusetts Agricultural College.

Drain, Harry D., ... Belpre, Ohio.
B.S.A., Ohio State University.

Etter, Art Edward, ... Monroe, Wis.
A.B., University of Wisconsin.

Fernald, Charles H., 2d, ... Amherst.
B.Sc., Massachusetts Agricultural College.

Fish, Ernest Ellsworth, ... Wyalusing, Pa.
B.Sc., Pennsylvania State College.

Fletcher, Arthur George, ... Orleans, Vt.
A.B., Harvard.

Hood, Egerton Gibson, ... Hagermon, Ontario, Can.
B.S.A., Toronto University.

[1] Enrollment from September, 1916, to January, 1917, inclusive. The list therefore does not represent the complete enrollment since Dec. 1, 1915.

Hubert, Benjamin F., ... Orangeburg, S. C.
B.Sc., Massachusetts Agricultural College.
Jones, Linus H., ... Milford.
B.Sc., Massachusetts Agricultural College.
Kelly, Harold R., ... Haverhill.
B.Sc., Massachusetts Agricultural College.
Kilham, Austin D., ... Springfield, Mo.
A.B., Drury College.
B.Sc. in agriculture, University of Missouri.
Knapton, Guy Lord, ... Lawrence.
B.Sc., Massachusetts Agricultural College.
MacNeil, Ralph Langdel, ... Amherst.
B.Sc., Massachusetts Agricultural College.
Mardfin, Emile, ... New York City.
B.Sc., Cornell University.
McNamara, M. J., ... Stoughton.
M.Sc., Massachusetts Agricultural College.
Merkle, Frederick Grover, ... Amherst.
B.Sc., Massachusetts Agricultural College.
Morgan, Ezra L., ... Amherst.
A.B., McKendree College.
M.A., University of Wisconsin.
Mutkekar, Satwaji Gundoji, ... Belgaum, Ind.
B.Agr., Poona Agricultural College.
Nash, Clayton W., ... South Weymouth.
B.Sc., Massachusetts Agricultural College.
Noyes, Henry Alford, ... Lafayette, Ind.
B.Sc., Massachusetts Agricultural College.
M.Sc., Massachusetts Agricultural College.
Pauley, William C., ... Lafayette, Ind.
B.Sc. in agriculture, Purdue University.
Peacock, Walter Miller, ... Bridgeton, N. J.
B.S., Cornell University.
M.S.A., Cornell University.
Peckham, Curtis, ... New Bedford.
B.Sc., Massachusetts Agricultural College.
Perry, Gerald Eugene, ... Amherst.
B.Sc., Massachusetts Agricultural College.
Porter, Bennet Allen, ... Amherst.
B.Sc., Massachusetts Agricultural College.
Prince, Arthur Leslie, ... Webster.
A.B., Clark College.
Purington, James A., ... Hopkinton, N. H.
B.Sc., New Hampshire College of Agriculture.
Ray, George Burrill, ... Hingham.
B.Sc., Massachusetts Agricultural College.
Root, Irving C., ... Kansas City, Kan.
B.Sc., Kansas State Agricultural College.
Rutledge, Ralph M., ... Amherst.
B.Sc., Oregon Agricultural College.
M.S., University of Wisconsin.
Serex, Paul, Jr., ... Bloomfield, N. J.
B.Sc., Massachusetts Agricultural College.
M.Sc., Massachusetts Agricultural College.
Stewart, Lloyd L., ... Darlington, Ind.
B.Sc. in agriculture, Purdue University.
Thompson, W. Bradley, ... Orange, N. J.
A.B., Williams College.
Vinal, Stuart C., ... East Weymouth.
B.Sc., Massachusetts Agricultural College.
Wheeler, John T., ... Amherst.
B.S.A., University of Wisconsin.

White, Donald, ... Wakefield.
A.B., Harvard College.
White, Henry Harrison, ... Amherst.
B.Sc., Massachusetts Agricultural College.
Wies, Calmy, ... Malden.
B.Sc., Massachusetts Agricultural College.
Wildon, Carrick E., ... Melrose Highlands.
B.Sc., Massachusetts Agricultural College.
Wood, Elwin G., ... Bigfork, Mont.
B.Sc., Washington State College.
Woodman, Allison Morris, ... Berkeley, Cal.
B.Sc. in agriculture, University of California.

In Absentia.

Davies, Ernest Langford, ... Guelph, Can.
B.Sc., Ontario Agricultural College.
Fletcher, Arthur George, ... Orleans, Vt.
A.B., Harvard College.
Noyes, Harry Alfred, ... Lafayette, Ind.
B.Sc., Massachusetts Agricultural College.
M.Sc., Massachusetts Agricultural College.

Class of 1917.

Babcock, Philip Rodney, [1]	Lynn,	Kappa Sigma.
Behrend, Oswald,	Natick,	Commons Club.
Bell, Alfred Whitney, Jr.,	West Newton,	53 Lincoln Avenue.
Boles, Robert Stewart,	Dorchester,	Beta Kappa Phi.
Bonn, Wesley Copeland,	Grafton,	Commons Club.
Booth, Alfred,	Campbell Hall, N. Y.,	12 South College.
Boyce, Harold Prescott, [1]	Haverhill,	14 South College.
Buckman, Lewis Taylor,	Wilkes-Barre, Pa.,	13 South College.
Buttrick, David Herbert,	Arlington,	Phi Sigma Kappa.
Carruth, Glenn Howard, [1]	Orange,	3 North College.
Chamberlin, Frank Shirley,	Framingham,	18 Nutting Avenue.
Clough, Charles Henry,	Dedham,	11 North College.
Cross, Walter Irving,	Hingham Center,	6 North College.
Curtin, Charles Warren,	Newton,	10 Hallock Street.
Davis, Monsell Henry,	Orange, N. J.,	16 North College.
Day, James Harold,	Hatfield,	85 Pleasant Street.
Dempsey, Paul Wheeler,	Dorchester,	15 North College.
Dickey, Harold Gammell,	Dorchester,	8 South College.
Dillon, Thomas Stevenson, [1]	West Warren,	Aggie Inn.
Dizer, John Thomas,	East Weymouth,	East Experiment Station.
Duffill, Edward Stanley,	Melrose Highlands,	8 Allen Street.
Dunham, Henry Gurney,	West Bridgewater,	11 North College.
Edwards, Francis Gill, [1]	Beverly,	Phi Sigma Kappa.
Elliot, Ralph William,	Chartley,	Flint Laboratory.
Everbeck, George Charles, [1]	Boston,	1 South College.
Fearing, Ralph Watson,	Dorchester,	3 North College.
Flagg, Wayne McCrillis,	Mittineague,	Beta Kappa Phi.
Flint, Oliver Simeon,	Lowell,	120 Pleasant Street.
Goldstein, Maurice,	Lynn,	10 North College.
Graham, Leland Jenkins,	Amherst,	Lincoln Avenue.
Grayson, Emory Ellsworth, [1]	Milford,	Alpha Sigma Phi.
Gurshin, Carl Alfred,	Lynn,	Kappa Sigma.
Hagelstein, Charles Henry,	Dorchester,	14 South College.
Harlow, Frank Edward, [1]	Malden,	10 North College.
Harlow, Paul Goodhue,	Malden,	Phi Sigma Kappa.
Henninger, Roswell Woodward,	Williamsport, Pa.,	87 Pleasant Street.

[1] Work incomplete.

Higginbotham, Harry,	Taunton,	3 South College.
Hill, Edmund Baldwin,	Rutherford, N. J.,	Alpha Sigma Phi.
Holden, Richard Lynde,	Haverhill,	11 South College.
Holder, Ralph Clifton,	Farmington, N. H.,	17 Kellogg Avenue.
Hubbell, Franklin Homer,	Westport, Conn.,	14 South College.
Irving, William Raymond,	Taunton,	13 South College.
Kelsey, Edmund Dean, [1]	Amherst,	Commons Club.
Kelsey, Lincoln David,	West Hartford, Conn.,	90 Pleasant Street.
Kinsman, Alfred Oberlin, Jr.,	Merrimac,	Mathematics Building.
Larson, Frederick Christian, [1]	Everett,	12 South College.
Latham, Paul Walker,	Norwichtown, Conn.,	12 North College.
Lawrence, Milford Robinson,	Falmouth,	Kappa Sigma.
Light, Brooks, [1]	Brookline,	4 South College.
Loring, Albert Briggs,	Nantasket Beach,	16 North College.
Lydiard, Harry Crowther,	Hartford, Conn.,	Colonial Inn.
Mack, Walter Adams,	Springfield,	15 South College.
MacLeod, Daniel Johnston, [1]	Wakefield,	Hillside Avenue, R. F. D. No. 126.
Marchant, Horace Greenough,	Cambridge,	5 North College.
Mayo, Frank Willard, [1]	Houlton, Me.,	Phi Sigma Kappa.
Mayo, William Irving, Jr.,	Framingham Center,	Experiment Station Farm House.
McNamara, Michael Joseph, [1]	Stoughton,	Stockbridge Hall.
Merrill, Daua Otis,	East Pepperell,	10 North College.
Moorhouse, Newell,	Worcester,	9 South College.
Nash, Herman Beaman,	Amherst,	13 North College.
Nelson, John Brockway,	Newburyport,	15 South College.
Noyes, Samuel Verne,	Georgetown,	11 North College.
Pierce, Harold Barnard,	Kansas City, Mo.,	80 Pleasant Street.
Pratt, Harold Arthur,	Shrewsbury,	M. A. C. Plant House.
Quimby, Charles Frederick,	Cape Neddick, Me.,	83 Pleasant Street.
Randall, Earle MacNeill,	Winchester,	11 South College.
Richardson, Lewis Elmer,	Rockville,	11 South College.
Rodger, Raymond Miller, [1]	Everett,	16 South College.
Rogers, Roland Winsor,	Braintree,	12 South College.
Rorstrom, Hans Alfred,	Boston,	Experiment Station Farm House.
Ross, Louis Warren, [1]	Boston,	Phi Sigma Kappa.
Saidel, Harry Samuel, [1]	Worcester,	101 Pleasant Street.
Sargent, George Leonard,	Merrimac,	4 North College.
Saunders, William Putnam,	Lawrence,	20 South College.
Sauter, John Martin,	Turners Falls,	13 North College.
Saville, William, Jr.,	Waban,	7 South College.
Schaefer, Leonard Charles,	Holyoke,	Entomology Building.
Schwab, Andrew Nathan,	Yalesville, Conn.,	French Hall.
Selkregg, Edwin Reimund, [1]	Northeast, Pa.,	North College.
Shumway, Paul Edward,	Greenfield,	3 South College.
Sims, James Stanley, [1]	Melrose,	20 South College.
Smith, Herbert Dwight, [1]	Amherst,	60 Pleasant Street.
Smith, Richard Woodworth,	Pittsfield,	12 North College.
Spaulding, Almon Whitney,	Newton Highlands,	16 South College.
Squires, Paul Revere,	Belchertown,	85 Pleasant Street.
Stearns, Carlton McIntyre, [1]	Melrose,	15 Phillips Street.
Stiles, Albert Ralph, [1]	Arlington Heights,	7 South College.
Stowell, Harold Thurber,	Amherst,	193 South Pleasant Street.
Thayer, William Wallace,	Somerville,	Lambda Chi Alpha.
Tuthill, Samuel Fuller,	Mattapoisett,	16 South College.
Upson, Everett Langdon,	New Britain, Conn.,	4 South College.
Walbridge, Henry Blood,	Bennington, Vt.,	4 North College.
Warner, Merrill Pomeroy, [1]	Sunderland,	8 South College.
Warren, Harold Manson, [1]	Melrose,	1 South College.
Warren, James Joseph,	North Brookfield,	3 North College.

[1] Work incomplete.

Webster, Frank Cedric,	Harvard,	Mathematics Building.
Westman, Robert Clayton,[1]	Roslindale,	15 South College.
Whitcomb, Warren Draper,	Waltham,	88 Pleasant Street.
Whitney, Joseph Fradley,	Westminster,	Kappa Sigma.
Wies, Calmy,	Malden,	31 Pleasant Street.
Wilber, Charles Raymond,	Walpole,	6 North College.
Wilcox, Timothy Palmer,	Andover,	1 North College.
Williams, Arthur Franklin,	Sunderland,	10 South College.
Williams, Herbert Clifton,	South Hadley Falls,	Birch Lawn.

CLASS OF 1918.

Additon, Elizabeth Emery,[1]	Newton Center,	Draper Hall.
Babbitt, George King,[1]	Boston,	85 Pleasant Street.
Bainbridge, Frank Benedict,[1]	Paterson, N. J.,	5 South College.
Baker, Foster Kenneth,	Fairhaven,	Entomology Building.
Baker, Henry Raymond,	Amherst,	West Street.
Barton, George Wendell,	North Sudbury,	36 North Prospect Street.
Binks, Frank Joseph,[1]	Maynard,	Beta Kappa Phi.
Boaz, William Henry,	Covesville, Va.,	Phi Sigma Kappa.
Boyd, Robert Lucius,[1]	Lynn,	Colonial Inn.
Bruce, Walter Griffith,	Springfield,	21 Fearing Street.
Buchanan, Walter Gray,	Chicopee,	97 Pleasant Street.
Canlett, Franklin Harwood,	Bedford,	36 North Prospect Street.
Carlson, Fred Albert,	Pittsfield,	84 Pleasant Street.
Carter, Thomas Edward,[1]	West Andover,	82 Pleasant Street.
Chamberlain, Sumner Fiske,[1]	Holden,	83 Pleasant Street.
Chambers, Roger James,	Dorchester,	9 North College.
Chapman, John Alden,	Salem,	Phi Sigma Kappa.
Clapp, Roger Francis,	Salem,	79 Pleasant Street.
Clark, Stewart Sandy,[1]	Holyoke,	Chemistry Laboratory.
Cotton, Elwyn Page,[1]	Woburn,	87 Pleasant Street.
Davis, Albert Noah,[1]	Somers, Conn.,	4 Chestnut Street.
Davis, Dwight Shaw,[1]	Woburn,	Commons Club.
Dowd, William Lawrence,[1]	North Amherst,	North Amherst.
Duncan, George James,[1]	Arlington,	101 Pleasant Street.
Dunn, Arthur Paul,[1]	Malden,	90 Pleasant Street.
Edes, David Oliver Nourse,	Bolton,	82 Pleasant Street.
Ellis, Ralph Chick,[1]	West Newton,	Colonial Inn.
Emmerich, Louis Philip,[1]	Paterson, N. J.,	6 South College.
Erickson, George Edwin,	Campello,	Lincoln Avenue.
Faneuf, Leo Joseph,[1]	West Warren,	Birch Lawn.
Farrar, Delwin Bruce,[1]	Amherst,	1 Dana Street.
Fellows, Harold Carter,[1]	Peabody,	Commons Club.
Ferris, Adaline Lawson,[1]	Ridgefield Park, N. J.,	Draper Hall.
Foley, William Albert,	Palmer,	35 North Prospect Street.
Foster, Hamilton Knight,[1]	New Rochelle, N. Y.,	4 Lessey Street.
Foster, Roy Wentworth,	Lynn,	82 Pleasant Street.
Francis, Donald Smith,[1]	Athol,	Beta Kappa Phi.
Fraser, Charles Allen,[1]	Plymouth,	Kappa Sigma.
Frellick, Arthur Lester,[1]	Everett,	13 Phillips Street.
Fuller, Camille Baldwin,[1]	West Quincy,	Commons Club.
Gasser, Thomas Jefferson,	Uxbridge,	Alpha Sigma Phi.
Gifford, Flavel Mayhew,	West Tisbury,	6 Nutting Avenue.
Gillette, Nathan Warner,[1]	Revere,	5 South College.
Goodridge, George Lucien,[1]	Melrose,	82 Pleasant Street.
Goodwin, William Irving,[1]	Bradford,	82 Pleasant Street.
Gordon, Frederick George,[1]	Plymouth,	Birch Lawn.
Gray, Milton Berford,	Woods Hole,	13 Phillips Street.
Grayson, Forrest,	Milford,	1 North College.

[1] Work incomplete.

Haines, Foster Kingsley,	Peabody,	120 Pleasant Street.
Hance, Forrest Sansbury,[1]	Paterson, N. J.,	Colonial Inn.
Harwood, Ralph Wallace,	Barre,	Phi Sigma Kappa.
Hawley, Robert Dorman,	Springfield,	Phi Sigma Kappa.
Hayes, Olin Henry,[1]	Lawrence,	7 Nutting Avenue.
Heffron, Paul John,[1]	Sherborn,	Birch Lawn.
Higgins, Leo Clement,[1]	Amesbury,	24 Beston Street.
Hilliker, Harriett Franklin,[1]	East Lynn,	9 Phillips Street.
Holmes, George Frederick,	Ipswich,	60 Pleasant Street.
Holmes, Robert Palmer,[1]	Wakefield,	Aggie Inn.
Howard, Arthur Merchant,	Pittsfield,	84 Pleasant Street.
Howe, Albert Edward,[1]	Needham,	Lincoln Avenue.
Howes, Donald Francis,	Ashfield,	Birch Lawn.
Hunnewell, Paul Fiske,	Winthrop,	Phi Sigma Kappa.
Huntoon, Douglas Henderson,	Norwood,	Phi Sigma Kappa.
Hurlburt, Ralph Walter,	Ashley Falls,	94 Pleasant Street.
Illman, Margaret Keble,[1]	Schuyler Falls, N. Y.,	Draper Hall.
Ingalls, Irving Weaver,[1]	Brooklyn, N. Y.,	Beta Kappa Phi.
Jepsky, Abraham,	Medway,	Birch Lawn.
Johnson, Birger Lars,[1]	Dorchester,	29 McClellan Street.
Kennedy, Carl Francis,[1]	Milford,	85 Pleasant Street.
Lanphear, Marshall Olin,	Windsor, Conn.,	96 Pleasant Street.
Lawrence, Lewis Henry,[1]	Falmouth,	79 Pleasant Street.
Lawton, Ralph Wilber,[1]	Fall River,	17 Fearing Street.
Leonard, Ralph Stanley,[1]	Melrose,	82 Pleasant Street.
Levine, Darwin Solomon,	Sherborn,	11½ Amity Street.
Lipshires, David Mathew,	Roxbury,	Flint Laboratory.
Loring, William Rupert,	Great Barrington,	Physics Building.
Lyons, Louis Martin,	Rockland,	East Experiment Station.
Maginnis, John Joseph,[1]	Lawrence,	Alpha Sigma Phi.
Mallorey, Alfred Sidney,[1]	Lynn,	15 Hallock Street.
Marshall, Max Skidmore,	Amherst,	44 Sunset Avenue.
McKee, William Henry,[1]	Chelsea,	M. A. C. Store.
McNaught, Warren Henry,	Plymouth,	Colonial Inn.
McRae, Herbert Rankin,[1]	Malden,	4 Nutting Avenue.
Messenger, Kenneth Leroy,	Winsted, Conn.,	Kappa Sigma.
Millard, Harold Baldwin,	Great Barrington,	Veterinary Building.
Minor, John Bacon, Jr.,[1]	New Britain, Conn.,	Kappa Sigma.
Mitchell, Edward Nahum,[1]	Medford,	Phi Sigma Kappa.
Mitchell, Theodore Bertis,	Needham,	15 North College.
Mower, Carl Taft,[1]	Montpelier, Vt.,	Kappa Sigma.
Moynihan, Patrick Joseph,[1]	Holyoke,	Alpha Sigma Phi.
Newton, Gaylord Arthur,	Durham, Conn.,	21 Fearing Street.
Norcross, Gardner Clyde,	Brimfield,	35 East Pleasant Street.
Odams, Lester Nichols,	Salem,	79 Pleasant Street.
Oertel, August Leonard,	South Hadley Falls,	Birch Lawn.
O'Heron, Francis James,[1]	East Milton,	5 North College.
O'Neill, Oliver Maurice,	Dorchester,	29 McClellan Street.
Patch, Lawrence Henry,	Wenham,	Plant House.
Petit, Arthur Victor,	Amherst,	31 East Pleasant Street.
Phipps, Clarence Ritchie,	Dorchester,	88 Pleasant Street.
Popp, Edward Williams,[1]	Albany, N. Y.,	9 North College.
Powell, James Congdon,	Newport, R. I.,	6 South College.
Pratt, Oliver Goodell,	Salem,	Kappa Sigma.
Preble, John Nelson,	Jamaica Plain,	Theta Chi.
Raymond, Clinton Rufus,	Beverly,	82 Pleasant Street.
Reumann, Theodore Henry,	New Bedford,	87 Pleasant Street.
Richardson, Stephen Morse,	Montague,	6 South College.
Ritter, Ernest,	New Britain, Conn.,	88 Pleasant Street.
Roberts, Oliver Cousens,[1]	Arlington,	88 Pleasant Street.

[1] Work incomplete.

Robinson, William Herbert,[1]	Hudson,	87 Pleasant Street.
Rosequist, Birger Reignold,[1]	New Bedford,	85 Pleasant Street.
Russell, Howard Leigh,	Worcester,	116 Pleasant Street.
Rutter, Walter Frederick,[1]	Lawrence,	17 Fearing Street.
St. George, Raymond Alexander,[1]	East Lynn,	Commons Club.
Sampson, Frederick Bucknam,[1]	Fall River,	60 Pleasant Street.
Sanborn, Deane Waldron,	Nantucket,	Birch Lawn.
Sawyer, Wesley Stevens,	Jamaica Plain,	Beta Kappa Phi.
Sawyer, William George,	Berlin,	8 South College.
Schlough, George Homer,[1]	Waltham,	82 Pleasant Street.
Schwartz, Louis,[1]	Melrose,	West Experiment Station.
Smith, Carleton Tower,	West Newton,	82 Pleasant Street.
Smith, Sidney Summer,	Roslindale,	3 Fearing Street.
Spaulding, Lewis Winans,[1]	Boston,	5 South College.
Stackpole, Frank Charles,[1]	Somerville,	15 North College.
Stjernlof, Axel Uno,	Worcester,	Farview Way.
Stowe, Raymond Timothy,	Scitico, Conn.,	51 Amity Street.
Stowers, Addison Clifford,	Dorchester,	South College.
Sullivan, Harold Leo,	Lawrence,	9 North College.
Swift, Raymond Walter,[1]	North Amherst,	North Amherst.
Thompson, Wells Nash,	Adams,	Alpha Sigma Phi.
Thorpe, Richard Warren,[1]	West Medford,	Phi Sigma Kappa.
Tilton, Arthur Dana,	Wellesley,	Phi Sigma Kappa.
Van Alstyne, Lewis Morrell,[1]	Kinderhook, N. Y.,	Phi Sigma Kappa.
Weeks, Roger Wolcott,[1]	Hyde Park,	Kappa Sigma.
Wilbur, Laurence Weston,[1]	South Middleborough,	Beta Kappa Phi.
Willoughby, Raymond Royce,	New Britain, Conn.,	24 Beston Street.
Wooding, Paul Bennett,[1]	Yalesville, Conn.,	M. A. C. Plant House.
Woodworth, Brooks,[1]	Lowell,	85 Pleasant Street.
Worthley, Harlan Noyes,	Greenwood,	Kappa Sigma.

Class of 1919.

Alden, Dean Watson,[1]	Proctor, Vt.,	Lambda Chi Alpha.
Bagg, Quincy Austin,[1]	South Hadley,	60 Pleasant Street.
Baker, William Alphonso,	Melrose,	Lambda Chi Alpha.
Baker, William Herbert, Jr.,	Chesterfield,	Theta Chi.
Batchelder, Stewart Putnam,	North Reading,	7 South College.
Batista, Victor,[1]	Havana, Cuba,	90 Pleasant Street.
Baxter, Herbert Hill,[1]	Brighton,	Alpha Sigma Phi.
Beadle, Herbert Ocumpaugh,[1]	Lima, N. Y.,	18 Nutting Avenue.
Bigelow, George Samuel,[1]	Millville, N. J.,	3 McClure Street.
Blanchard, Carlton Douglas,[1]	Uxbridge,	Kappa Sigma.
Blanchard, George Kinson,	Abington,	Kappa Sigma.
Bőgholt, Carl Miller,[1]	Newport, R. I.,	27 Pleasant Street.
Boland, Kells Shepard,[1]	South Boston,	120 Pleasant Street.
Bond, Herbert Richard,	Needham,	Lincoln Avenue.
Bowen, Arthur Newton,[1]	Wollaston,	15 Phillips Street.
Bowen, Maurice Stetson,[1]	Middleborough,	81 Pleasant Street.
Boyce, Alan Freeman,	Melrose,	83 Pleasant Street.
Boynton, Raymond Woods,[1]	Framingham,	85 Pleasant Street.
Bradley, William George,[1]	Groton,	88 Pleasant Street.
Brigham, Sylvia Bowen,	Newtonville,	Draper Hall.
Brown, Ralph Hall,[1]	Ayer,	Kappa Sigma.
Buffum, Eliot Mansfield,	Waban,	10 South College.
Burt, Henry John,	Arlington,	10 Allen Street.
Burton, Lee Williams,	Plainville,	35 East Pleasant Street.
Callanan, John Edward,[1]	Dorchester,	60 Pleasant Street.
Callanan, Vincent DePaul,	Malden,	4 Chestnut Street.
Carpenter, Hall Bryant,[1]	Somerville,	Kappa Sigma.
Carroll, Olive Evangeline,[1]	Dorchester,	Draper Hall.

[1] Work incomplete.

Cassidy, Morton Harding,[1]	East Boston,	82 Pleasant Street.
Castle, George Burdette,[1]	Pittsfield,	77 Pleasant Street.
Chandler, Arthur Lincoln,	Leominster,	3 Nutting Avenue.
Chapin, Frederic Charles,	Greenfield	West Experiment Station.
Chase, Malcolm Willis,[1]	Amesbury,	94 Pleasant Street.
Chisholm, Robert Dudley,	Melrose Highlands,	66 Pleasant Street.
Clapp, Agustus Warren,	East Braintree,	Lambda Chi Alpha.
Coderre, Ernest Laurier,	Southbridge,	35 North Prospect Street.
Collins, Robert Burleigh,	Rockland,	88 Pleasant Street.
Cone, Willis Refine,[1]	Mittineague,	42 McClellan Street.
Cooley, Edwin Prince,	Sunderland,	Sunderland.
Cosby, Alfred Francis,	Westfield,	15 Amity Street.
Crane, Arthur Francis,[1]	North Hanover,	24 Beston Street.
Crimmin, Royce Brainerd,[1]	Bradford,	82 Pleasant Street.
Crowe, Charles,	Norwich, Conn.,	Kappa Sigma.
Davies, James Pillsbury,	Cambridge,	6 Phillips Street.
Day, Harold Ralph,	Milford,	North College.
Dickinson, Victor Abel,[1]	Amherst,	Mount Pleasant.
Dunbar, Charles Oliver,	Westfield,	84 Pleasant Street.
Erhard, Bena Gertrude,	East Milton,	Draper Hall.
Erickson, Gunnar Emmanuel,	West Lynn,	29 McClellan Street.
Evans, Myrton Files,	West Somerville,	Kappa Sigma.
Faber, Edward Stuart,	Plainfield, N. J.,	M. A. C. Store.
Faneuf, Ambrose Clement,[1]	West Warren,	Birch Lawn.
Farrington, Robert Pierce,[1]	Nantucket,	15 Beston Street.
Faxon, Paul,[1]	Wellesley Hills,	66 Pleasant Street.
Fellows, Katharine Adelheid,	Northampton,	21 Amity Street.
Ferriss, Samuel Boynton,	New Milford, Conn.,	Beta Kappa Phi.
Field, Wilbert Daniel,[1]	Winter Hill,	29 McClellan Street.
Fiske, Eustace Bridge,	Somerville,	6 Nutting Avenue.
Fogg, Verne Allen,	Topsfield,	4 Chestnut Street.
Fox, Charles,	Baltimore, Md.,	17 Kellogg Avenue.
French, Willard Kyte,	Worcester,	6 Phillips Street.
Garde, Earl Augustus,	Lynn,	30 North Prospect Street.
Garvey, Mary Ellen Monica,	Amherst,	27 South Prospect Street.
Gilligan, Gerald Mathew,[1]	West Warren,	120 Pleasant Street.
Glavin, William Francis,	Wenham,	North College.
Goff, Howard Mason,	Cambridge,	120 Pleasant Street.
Graves, Walter Decker,[1]	Brookline,	1 North College.
Green, Lynn,	Schenevus, N. Y.,	6 Nutting Avenue.
Guba, Emil Frederick,	New Bedford,	6 Nutting Avenue.
Hall, Frank Edwin,[1]	Revere,	103 Pleasant Street.
Hamilton, Howard Milton,[1]	Winchester,	Cottage Street.
Harding, George Warren,[1]	Somerville,	Flint Laboratory.
Harris, Ethel Lovett,[1]	Beverly,	Draper Hall.
Hartwell, Richard Raymond,[1]	Springfield,	Colonial Inn.
Harvey, Ebenezer Erskine,[1]	Washington, D. C.,	Physics Building.
Hastings, Louis Pease,	Springfield,	Kappa Sigma.
Hathaway, Wilfred Adelbert,[1]	Taunton,	88 Pleasant Street.
Hodgson, Benjamin Earl,	Methuen,	22 Amity Street.
Hopkins, George Randolph Lawrence.	Orleans,	60 Pleasant Street.
Howe, Ralph Thomas,	Melrose Highlands,	120 Pleasant Street.
Hunter, Harold Clayton,[1]	South Hadley Falls,	60 Pleasant Street.
Jewell, Charles Henry,	Merrimac,	17 Kellogg Avenue.
Johnson, Lawrence Wilhelm,	Avon,	12 Cottage Street.
Johnson, Sidney Clarence,	Gloucester,	Beta Kappa Phi.
Jordan, Raymond Douglas,[1]	Springfield,	21 Fearing Street.
Kennedy, Alan Giles,[1]	Milford,	85 Pleasant Street.
Kimball, William Lincoln,[1]	Orange,	35 East Pleasant Street.
King, William Cutting,[1]	Suffield, Conn.,	120 Pleasant Street.

[1] Work incomplete.

Knight, Frank Edward,[1] .	Brimfield, . . .	35 East Pleasant Street.
Knowlton, Priscilla,[1] . .	Roxbury, . . .	M. A. C. Farm House.
Leary, Frank Dennis, . .	Brockton, . . .	12 Cottage Street.
Leiper, McCarrell Hudson, .	Blauvelt, N. Y., . .	Lincoln Avenue.
Liebman, Anna, . . .	Dorchester, . . .	Draper Hall.
Logan, Milan Alexander, .	Brockton, . . .	Lincoln Avenue.
Mansell, Elton Jessup,[1] . .	Cambridge, . . .	4 Chestnut Street.
Martin, Andrew Laurence,[1] .	Hopedale, . . .	Colonial Inn.
Mather, William, . . .	Amherst, . . .	Fitts House.
Mattoon, Charles Gordon, .	Pittsfield, . . .	120 Pleasant Street.
McCarthy, Arthur Martin, .	Monson, . . .	9 South College.
McClellan, Adams Newton, .	Keene, N. H., . .	Kappa Sigma.
Montgomery, Forest Kimball,[1]	East Orange, N. J., . .	87 Pleasant Street.
Moor, Erwin Charles,[1] . .	Lynn, ...	10 Allen Street.
Moore, John Raymond, . .	Tolland, . . .	Birch Lawn.
Morgan, Earl Amos,[1] . .	Amherst, . . .	2 Allen Street.
Morse, Maurice, . . .	Dorchester, . . .	Entomology Building.
Morton, Elmer Joshua,[1] . .	Watertown, . . .	Commons Club.
Newbold, Douglas Tracy, .	Northampton, . .	87 Pleasant Street.
Newton, Adelbert,[1] . .	Lenox, ...	77 Pleasant Street.
Newton, Edward Buckland,[1] .	Boston, . . .	Chemistry Laboratory.
O'Hara, Joseph Ernest, . .	Worcester, . . .	6 Phillips Street.
Parke, Robert Warren, . .	Winchendon, . . .	5 Allen Street.
Parkhurst, Raymond Thurston,	Fitchburg, . . .	Kappa Sigma.
Parsons, Edward Field, . .	North Amherst, . .	North Amherst.
Peck, George Newberry, . .	North Granby, Conn., .	10 Allen Street.
Peck, Roger Eugene,[1] . .	Shelburne, . . .	6 Nutting Avenue.
Peirson, Henry Byron, . .	Bradford, . . .	18 Nutting Avenue.
Perry, Errol Clinton,[1] . .	Acushnet, . . .	15 Hallock Street.
Peterson, Leroy Duane,[1] .	Brooklyn, N. Y., . .	120 Pleasant Street.
Pierpont, Frederick Trowbridge,	Chester, Pa., . . .	18 Nutting Avenue.
Pond, Allan Leon, . . .	Holliston, . . .	Kappa Sigma.
Poole, Harold Walter,[1] . .	Hudson, . . .	Beta Kappa Phi.
Prée, Karl Julius, . . .	Brookline, . . .	88 Pleasant Street.
Pulley, Marion Gertrude,[1] .	Melrose, . . .	2 Allen Street.
Quimby, Arthur Edmund, .	Boston, . . .	36 North Prospect Street.
Ratner, Charles Cosrael, . .	Springfield, . . .	3 Pleasant Street.
Rea, Julian Stuart, . .	East Weymouth, . .	Lincoln Avenue.
Readio, Roger Frank, . .	Florence, . . .	90 Pleasant Street.
Record, Harold Jordan,[1] .	West Boylston, . .	Butterfield Avenue.
Rice, Harold Miller, . .	Cheshire, . . .	Stockbridge Hall.
Robbins, Waldo Whiting, .	South Hingham, . .	14 Nutting Avenue.
Roberts, Mark Anthony, .	Dorchester, . . .	25 Lincoln Avenue.
Ross, Donald,[1] . . .	Boston, . . .	Phi Sigma Kappa.
Rowe, Clifford Alton,[1] . .	East Orange, N. J., .	Phi Sigma Kappa.
Sargent, Walter Harriman,[1] .	Malden, . . .	Draper Hall.
Schenkelberger, Frederic,[1] .	Quincy, . . .	10 South College.
Seavey, Paul Stanley,[1] . .	Cambridge, . . .	Commons Club.
Sedgwick, Alfred, . . .	Fall River, . . .	85 Pleasant Street.
Sexton, Ernest Francis,[1] . .	Darien, Conn., . .	3 Nutting Avenue.
Sheldon, Howard Rhoades, .	Mill River, . . .	4 Chestnut Street.
Sibley, Helen Aramintha, .	Longmeadow, . .	Draper Hall.
Skinner, Everett Hamilton,[1] .	West Upton, . . .	Kappa Sigma.
Smith, Jonathan Harold, .	Roslindale, . . .	88 Pleasant Street.
Smith, Wendell Frederick, .	Troy, N. Y., . . .	10 Allen Street.
Spaulding, Harold Edwin, .	Milford, . . .	Kappa Sigma.
Spencer, Arthur Winthrop,[1] .	Danvers, . . .	North College.
Stafford, Irving Boynton, .	Fall River, . . .	6 Nutting Avenue.
Stearns, Horace David, . .	Waltham, . . .	18 Nutting Avenue.
Stevens, Chester Dillingham, .	Reading, . . .	10 Allen Street.
Stockwell, Erwin Sidney, Jr., .	Sharon, . . .	Commons Club.

[1] Work incomplete.

Strack, Edward,	Framingham,	Clark Hall.
Sutherland, Ralph,	Cambridge,	85 Pleasant Street.
Sweeney, William Joseph,[1]	Dorchester,	35 North Prospect Street.
Taylor, Edmund Billings,	Wollaston,	17 Fearing Street.
Thayer, Julian Bailey,	Durham Center, Conn.,	36 North Prospect Street.
Thayer, Weston Cushing,[1]	Hingham,	53 Lincoln Avenue.
Thomas, Frank DesAutel,[1]	Milford,	Lincoln Avenue.
Tietz, Harrison,	Richmond Hill, N. Y.,	24 Beston Street.
Tirrell, Loring Vinson,[1]	South Weymouth,	Lincoln Avenue.
Underwood, Arthur Leslie,	Maynard,	Beta Kappa Phi.
Vickers, John,	Amherst,	Beta Kappa Phi.
Waite, Richard Austin,	Middlefield,	90 Pleasant Street.
Wells, Marion Nichols,	Springfield,	Draper Hall.
Wheeler, Russell Hubbell,[1]	Hawleyville, Conn.,	4 Chestnut Street.
White, Edward Asa,	Providence, R. I.,	4 Chestnut Street.
Whittle, Clarence Parker, Jr.,[1]	Weymouth,	Phi Sigma Kappa.
Williams, Allan Carruth,	Rockland,	Commons Club.
Williams, Kenneth Sanderson,[1]	Sunderland,	9 South College.
Window, James Joseph,	Amherst,	7 Allen Street.
Wing, Arland Junius,	Hathorne,	North College.
Wood, Oliver Wiswell,	Arlington,	81 Pleasant Street.
Woodard, Chester Smith,[1]	Leverett,	Leverett.
Woodbury, Ray Willard,[1]	Newburyport,	Cottage Street.
Woodside, Wilfred Livingstone,	Boston,	4 Chestnut Street.
Yesair, John,[1]	Byfield,	Kappa Sigma.

Class of 1920.

Allen, Harold Kenneth,	Belchertown,	Belchertown.
Anderson, George,	Somerville,	1 South College.
Anderson, Gust William,[1]	Brockton,	Lincoln Avenue.
Andrews, George Henry,	Farmington, Conn.,	1 School Street.
Apsey, George Wills, Jr.,[1]	Winchester,	17 Phillips Street
Armstrong, John Shepard,[1]	East Sandwich,	35 East Pleasant Street.
Armstrong, Philip Brownell,[1]	Rutherford, N. J.,	Farview Way.
Babcock, Leslie Edmund,[1]	Marlborough,	36 North Prospect Street.
Bacon, Milo Roderick,	Leominster,	87 Pleasant Street.
Bailey, William,	Williamstown,	25 Pleasant Street.
Ball, Harry Abraham,	Bridgewater,	5 Sunset Avenue.
Ball, Lorin Earl,	Amherst,	3 Allen Street.
Beauregard, Winfield Scott,	Framingham,	53 Lincoln Avenue.
Berman, Harry,	Holyoke,	Birch Lawn.
Berman, Louis,[1]	Dorchester,	41 Pleasant Street.
Bigelow, Henry Charles,	Millville, N. J.,	3 McClure Street.
Blake, Robert Austin,[1]	Wollaston,	Pleasant Street.
Blanchard, Kenneth,[1]	Haverhill,	8 Nutting Avenue.
Boardman, Charles Meade,	Amherst,	33 Lincoln Avenue.
Bowen, Abram Temple,[1]	Granville, N. Y.,	7 Allen Street.
Bowmar, Ralph Burton,	Canton,	29 North Prospect Street.
Bridge, James Pitts,[1]	San Antonio, Tex.,	120 Pleasant Street.
Brown, Roy Robertson,	Wollaston,	Sunny Villa.
Bunker, Carroll Wooster,	West Somerville,	4 Nutting Avenue.
Burnett, Paul Lapham,	Leicester,	5 Nutting Avenue.
Burns, Allan Melville,	Taunton,	83 Pleasant Street.
Cande, Robert Parsons,	Pittsfield,	5 Fearing Street.
Card, Ralph Hunter,	Somerville,	3 Nutting Avenue.
Carleton, John Foxcroft,	East Sandwich,	35 East Pleasant Street.
Center, Arthur Edwin,[1]	Springfield,	73 Pleasant Street.
Chase, Francis Chapin,	Royalston,	35 East Pleasant Street.
Clarridge, Fred William,	Milford,	Lincoln Avenue.
Clough, Alfred Arnold,	Wollaston,	Sunny Villa.
Cole, Frederick Eugene, Jr.,	South Portland, Me.,	29 McClellan Street.

[1] Work incomplete.

Crafts, Gordon Burnham,	Manchester,	25 Pleasant Street.
Crawford, Alexander George,[1]	Waverley,	10 Nutting Avenue.
Crawford, John Alexander,	Allston,	10 Allen Street.
Daggett, Clinton Jones,	New York, N. Y.,	23 Lincoln Avenue.
Davenport, Frank Sémore,[1]	Dorchester,	Lincoln Avenue.
Davidson, Donald Gordon,	Amherst,	7 Northampton Road.
Davis, Orrin Chester,	Belchertown,	Belchertown.
Delahunt, John Kersey,[1]	Boston,	10 Nutting Avenue.
Derick, Glendon Robert,	Clinton,	36 North Prospect Street.
Dewing, Warren Montague,	Kingston,	31 East Pleasant Street.
Dixon, Harry Louis,	Harrisville, R. I.,	66 Pleasant Street.
Doucette, Charles Felix,	Melrose,	Hillside Avenue.
Douglass, Donald Churchill,	Arlington,	3 Nutting Avenue.
Dwyer, James Edward,	Sunderland,	Alpha Sigma Phi.
Earley, Marion Edith,[1]	West Newton,	9 Phillips Street.
Eldredge, Reuel West,	Winchester,	Pease Avenue.
Emery, Herbert Martin,[1]	Newburyport,	Cottage Street.
Farnsworth, Richard Wasgatt,	Lancaster,	7 East Pleasant Street.
Fuller, Lorenzo,	Lowell,	7 Nutting Avenue.
Gaskill, Harland Everett,[1]	Hopedale,	North Pleasant Street.
Gay, Laurence Washburn,	Groton,	88 Pleasant Street.
Golosov, James Sidney,	Dorchester,	67 Pleasant Street.
Gorwaiz, Richard Hamblet,	Newburyport,	66 Pleasant Street.
Graff, Leland Sprague,[1]	Reading,	10 Allen Street.
Graves, Carlisle Ferrin,	Stamford, Conn.,	7 Allen Street.
Gray, Irving Emery,	Woods Hole,	13 Phillips Street.
Gustafson, William Nathaniel,[1]	Worcester,	5 Nutting Avenue.
Hale, Frank Thompson Caldwell,	Byfield,	66 Pleasant Street.
Hamlin, Hazen Wolcott,[1]	Amherst,	35 East Pleasant Street.
Harrington, Harold Leon,	Lunenburg,	44 Triangle Street.
Haskins, Harold Arthur,	North Amherst,	North Amherst.
Hathaway, Richmond Hobson,	Warren,	35 East Pleasant Street.
Hathaway, Warren Sidney,[1]	Somerset,	75 Pleasant Street.
Haynes, Charles Francis,[1]	Canton,	36 North Prospect Street.
Hemenway, Carl Marshall,[1]	Williamsburg,	73 Pleasant Street.
Hersom, Allen Humphrey,[1]	Acushnet,	46 Pleasant Street.
Higgs, John Alden,	Wareham,	120 Pleasant Street.
Hill, John Farren,[1]	Scituate,	Pease Avenue.
Hill, Theodore, Jr.,	Jefferson Valley, N. Y.,	44 Triangle Street.
Hillabold, Charles Kroh,	Syracuse, Ind.,	Mount Pleasant.
Holland, Frank Harold,[1]	Shrewsbury,	73 Pleasant Street.
Holloway, John William,	Taunton,	81 Pleasant Street.
Horne, Robert Sanderson,	Wellesley Farms,	77 Pleasant Street.
Howland, George Herbert,[1]	Melrose,	120 Pleasant Street.
Hurd, Davis Alden,	Wellesley Hills,	36 North Prospect Street.
Hurd, Gordon Killam,	Millbury,	36 North Prospect Street.
Hyde, Kenneth Squier,	Amherst,	51 Pleasant Street.
Iorio, Carlo Antonio,	Springfield,	75 Pleasant Street.
Jakeman, Brooks Franklin,[1]	Winchester,	116 Pleasant Street.
Johnson, Alberta,	Old Westbury, L. I.,	M. A. C. Farm House.
Johnson, Conrad John,	Campello,	15 Hallock Street.
Jones, Edson Temple,[1]	Roslindale,	42 McClellan Street.
Jones, Robert Lambert,	North Easton,	5 McClellan Street.
Keene, Walter William,	Roslindale,	12 Cottage Street.
King, Starr Margetts,	Pittsfield,	5 Fearing Street.
Lambert, Richard Bowles,[1]	Stow,	21 Amity Street.
Lent, Donald Ashford,	Maynard,	35 East Pleasant Street.
Levine, Maurice Eleazer,	Sherborn,	Lincoln Block.
Liang, Ping,	Canton, China,	21 Fearing Street.
Lindquist, Harry Gotfred,	Holden,	15 Hallock Street.
Littlefield, John Edwin,	Lynn,	15 Hallock Street.
Lothrop, Earle Daniel,	West Bridgewater,	77 Pleasant Street.

[1] Work incomplete.

Luce, William Alan,	West Boylston,	4 Chestnut Street.
Lyons, Henry Egmont,	Norwell,	29 North Prospect Street.
MacArdle, Herbert Aloysius,[1]	Worcester,	Colonial Inn.
MacLeod, Guy Franklin,	Lowell,	Lincoln Avenue.
Mallon, Charles Hugh,	East Braintree,	75 Pleasant Street.
Mangum, Andrew Bruyette,[1]	Holyoke,	60 Pleasant Street.
Maples, James Comly,	Port Chester, N. Y.,	81 Pleasant Street.
Martin, Laurence Paul,	Malden,	6 Phillips Street.
McDonald, Milton Crandall,	Peabody,	120 Pleasant Street.
McGeorge, William Brimble,	Greenwich, Conn.,	3 McClellan Street.
McNulty, Raymond Henry,	Amherst,	6 South East Street.
Meserve, Albert Wadsworth,[1]	Framingham,	53 Lincoln Avenue.
Millard, Helen Stanley,	Great Barrington,	M. A. C. Farm House.
Munroe, Raymond Franklin,	Fall River,	Commons Club.
Murray, Harry Athol, Jr.,[1]	Raynham Centre,	81 Pleasant Street.
Mutty, Allan Victor,[1]	Boston,	4 Chestnut Street.
Newell, Philip Sanger,	West Newton,	35 East Pleasant Street.
Oppe, Herman DeWitt,	Newtown, Conn.,	94 Pleasant Street.
Ortloff, Henry Stuart,[1]	Newton,	Clark Hall.
Paige, Joseph Cutler,[1]	Hardwick,	7½ East Pleasant Street.
Parkin, William Hildreth,	West Springfield,	Tillson Court.
Peckham, William Harold,[1]	Newport, R. I.,	81 Pleasant Street.
Phillips, Stephen Austin,[1]	Pittsfield,	75 Pleasant Street.
Plowman, George Taylor, Jr.,	Winthrop,	13 Phillips Street.
Porteck, Henry George,[1]	Lowell,	Lincoln Avenue.
Putnam, Frederic Henry,[1]	Framingham,	73 Pleasant Street.
Quadland, Howard Preston,[1]	North Adams,	81 Pleasant Street.
Quincy, Percy Edmund,[1]	Allston,	7 Nutting Avenue.
Readio, Philip Adna,	Florence,	120 Pleasant Street.
Redding, George Kenneth,	Melrose,	29 Pleasant Street.
Reed, Morris,[1]	Worcester,	73 Pleasant Street.
Richards, George Henry,	Springfield,	15 Phillips Street.
Richardson, Mark Morton,	North Dana,	8 Nutting Avenue.
Roberts, Ivan Andrew,[1]	South Lee,	3 McClellan Street.
Robertson, Lafayette Janes, Jr.,[1]	Hartford, Conn.,	29 Pleasant Street.
Robertson, William Fenton,[1]	Framingham,	53 Lincoln Avenue.
Sanborn, Joseph Raymond,[1]	North Amherst,	North Amherst.
Sanderson, Ralph Hemmenway,	Waltham,	42 McClellan Street.
Schandelmayer, Ralph Ernest,[1]	Marlborough,	Stockbridge Hall.
Scott, Clifton William,[1]	Buckland,	14 Nutting Avenue.
Shaughnessy, Howard John,	Easthampton,	17 Phillips Street.
Silverman, Joseph,[1]	Dorchester,	5 Nutting Avenue.
Simmons, Lester Winslow,	Dighton,	75 Pleasant Street.
Smith, Donald Hiram,[1]	Pittsfield,	77 Pleasant Street.
Smith, Fred George,	Otter River,	72 Main Street.
Smith, George Alfred,	Whitinsville,	Lincoln Avenue.
Smith, Herbert Thatcher,	Atlantic,	Sunny Villa.
Smith, Raymond Archer,[1]	Maynard,	35 East Pleasant Street.
Smith, Raymond Newton,[1]	Plainville,	35 East Pleasant Street.
Smith, Susan Almira,	Great Barrington,	M. A. C. Farm House.
Snow, John Dow,[1]	Arlington,	77 Pleasant Street.
Spencer, William,	Worcester,	McClure Street.
Steacie, Curtis,	Framingham,	17 Phillips Street.
Stedman, Ralph Shaw,[1]	Springfield,	15 Phillips Street.
Stiles, William Burling,	Great Barrington,	4 Chestnut Street.
Strecker, Edmund Herman,	New York, N. Y.,	3 McClellan Street.
Sullivan, Walter Mitchell,[1]	Lawrence,	Lincoln Avenue.
Sumner, Ralph Martin,	Springfield,	35 East Pleasant Street.
Sweeney, Frank Joseph,	Whitman,	12 Cottage Street.
Talmage Harry John,	Alford,	21 Amity Street.
Taylor, Elliot Hubbard,	Shelburne,	North Amherst.
Taylor, Thornton Greenwood,	Brookline,	103 Butterfield Avenue.

[1] Work incomplete.

Torrey, Converse Hall,[1]	Williamstown,	25 Pleasant Street.
Turner, Alfred William,[1]	Santo Domingo,	53 Lincoln Avenue.
Urquhart, John Wardrop	East Walpole,	Hallock Street.
Vigezzi, John Dellea,	Great Barrington,	75 Pleasant Street.
Vigezzi, Mary Theresa,	Great Barrington,	M. A. C. Farm House.
Ware, Mason,[1]	Malden,	6 Phillips Street.
Waugh, Frederick Vail,	Amherst,	Amherst.
Webster, Milton Fuller,[1]	Malden,	73 Pleasant Street.
Willis, Maud Ethel,[1]	Amherst,	13 Cottage Street.
Woodward, Ralph, Jr.,[1]	Grafton,	7 Nutting Avenue.
Wright, Kenneth Yerxa,[1]	Arlington,	77 Pleasant Street.
Wright, Stuart Eldridge,	Taunton,	53 Lincoln Avenue.

Unclassified Students.

Allen, Arthur Frederic,	Boston,	The Perry.
Avery, Humphrey Roger,	Patchogue, N. Y.,	86 Pleasant Street.
Berry, Fred Mitchell,[1]	Lynnfield Center,	120 Pleasant Street.
Blanchard, Margery Elizabeth,	Linwood,	79 Pleasant Street.
Bridgman, Ralph Scofield,	Westhampton,	60 Pleasant Street.
Buck, Paul Ten Hagen,	La Grangeville, N. Y.,	6 Allen Street.
Campbell, John Collins,	Gardner,	35 North Prospect Street.
Clancy, Henry Gregory,[1]	Natick,	35 North Prospect Street.
Cross, Robert Earle,	Agawam,	21 Fearing Street.
Curran, Ralph Aloysius,	East Boston,	5 Allen Street.
Davis, Edwin John,	Holyoke,	35 East Pleasant Street.
Emerson, Caroline Dwight,	Amherst,	21 Northampton Road.
Floersh, Mary Frances,	Nashville, Tenn.,	Draper Hall.
Giles, John Farrar,	South Lincoln,	1 Cottage Street.
Grundler, Adolph Joseph,	Lowell,	Poultry Plant.
Harris, Warren Timothy,	Millbury,	60 Pleasant Street.
LaPoint, Wilfred John,	Greenfield,	6 Allen Street.
Messmer, Robert Frederick,	Milwaukee, Wis.,	10 Allen Street.
Morton, Leander Paul	Amherst,	Lincoln Avenue.
Norris, Harold Allison,[1]	Amherst,	Birch Lawn.
Novitski, Joseph Francis,	Amherst,	Amherst.
Palmer, Philip Leonard,	Springfield,	Lincoln Avenue.
Rollins, Eva Isolde,	Amherst,	21 Main Street.
Rucker, Harriett Evans,	Amherst,	5 School Street.
Scott, John Edmund,	Fort Wayne, Ind.,	6 Allen Street.
Searls, Edward Marlborough,	Schaghticoke, N. Y.,	North Amherst.
Watson, Hawkesworth Douglas,	Walpole,	5 Allen Street.
Whitman, Luther Oakes,	Amherst,	29 Pleasant Street.
Woods, Frank Archibald,	Groton,	83 Pleasant Street.

Vocational Poultry Students.

Alden, Margaret E.,	Abington,	17 Kellogg Avenue.
Anderson, Ernest Emil,	Medford,	7 Nutting Avenue.
Andrews, Nelson Irving,	Hyde Park,	35 East Pleasant Street.
Churchill, Oliver Claude,	West Somerville,	44 Triangle Street.
Coleman, Moses Milton,	Mendon,	Farview Way.
Fitzgerald, Albert Joseph,	Braintree,	Poultry Plant.
Hallock, Genevieve,	Westborough,	4 Chestnut Street.
Savage, John Batcheller,	Cambridge,	12 Nutting Avenue.

[1] Work incomplete.

Geographical Summary.

Massachusetts,	567
Connecticut,	27
New York,	25
New Jersey,	16
Indiana,	7
Pennsylvania,	5
Rhode Island,	5
New Hampshire,	4
Vermont,	4
Maine,	3
Michigan,	3
Tennessee,	3
Missouri,	2
Canada,	2
Wisconsin,	2
California,	1
District of Columbia,	1
Kansas,	1
Maryland,	1
Mississippi,	1
Montana,	1
Ohio,	1
South Carolina,	1
Texas,	1
Virginia,	1
China,	1
Cuba,	1
France,	1
India,	1
Santo Domingo,	1
Total,	690

Summary by Classes.

Graduate students,	67
Senior class, 1917,	104
Junior class, 1918,	138
Sophomore class, 1919,	174
Freshman class, 1920,	170
Unclassified students,	29
Vocational poultry students,	8
Total registration,	690

Short Course Students, 1916.

The Ten Weeks' Course.

Ahrens, George,	Springfield.
Allen, Wm. R.,	Maylan, Pa.
Alvarez, Frederic G.,	Springfield.
Anderson, Ernest,	Amherst.
Archambo, David P.,	Griswoldville.
Bailey, Roland S.,	Kingston.
Beaman, Lawrence H.,	Leverett.
Bent, Whitney J.,	Maynard.
Bertolf, August C.,	Greenwich.
Bisbee, P. E.,	Amherst.
Blackmer, John W.,	Orange.
Blackwelle, Malcolm G.,	Fairhaven.
Blake, Robert A.,	Wollaston.
Brady, James,	Petersham.
Brooks, Roger E.,	Worcester.
Bryan, Lester W.,	Worcester.
Buckley, John,	Newburyport.
Burt, Gordon E.,	Plainfield.
Carley, Mrs. H. S.,	Amherst.
Chadwick, John T., Jr.,	West Boxford.
Challet, Fred E.,	Northampton.
Chamberlain, Harlan E.,	Abington.
Cheney, Waldo E.,	Dedham.
Childs, Alexander G., Jr.,	Dorchester.
Clapp, Robert,	Northampton.
Cole, E. Francis,	Dedham.
Cole, Emma M.,	Dedham.
Corbin, Erford H.,	Palmer.
Coristine, Mrs. Mary S.,	Amherst.
Coristine, Walter H.,	Amherst.
Cox, Ralph E.,	Wakefield.
Crocker, John A.,	Newton.
Cromack, Leslie G.,	Bardwell's Ferry.
Cudworth, Robert P.,	Melrose Highlands.
Dana, Carlos E.,	Oxford.
Daniels, George H.,	Newton.
Davidson, Harold J.,	Auburn.
Delvey, Ernest,	Turners Falls.
Doran, Albert J.,	Lynn.
Dorling, Herbert,	Spencer.
Downey, Clifton W.,	Maynard.
Dragon, Raymond,	Northampton.
Dunn, Ralph C.,	Mattapoisett.
Durant, Herbert R.,	Leverett.
Durfee, Volney L.,	Bristol.
Emerson, Carl E.,	Waltham.
Erickson, Harry,	Westford.
Erikson, Paul F.,	Rockland.
Estes, Lawrence H.,	Windsor.
Ewing, Stanley M.,	Easthampton.
Farrell, Thomas E.,	Pittsfield.

Fay, Allen M.,	Watertown.
Ferris, Adaline L.,	Ridgefield Park, N. J.
Fiske, Wm.,	Northampton.
Frye, Howard S.,	Lunenburg.
Fuller, Sears,	Roxbury.
Gale, George T.,	Springfield.
Galusha, G. Newell,	Williamstown.
Gillette, Kent,	Collinsville.
Grant, Gladys M.,	Brockton.
Groff, Paul W.,	Amherst.
Hammond, Burton H.,	Onset.
Hanrahan, John B.,	Lawrence.
Hansburg, Philip, Jr., 2d,	Hartford, Conn.
Hardy, Fred C.,	Lancaster.
Harrington, Carl R.,	Lunenburg.
Harris, W. T.,	Millbury.
Heine, Mrs. Helen M.,	State Line.
Higgins, Robert H.,	Arlington.
Hildreth, Leon F.,	Westford.
Hold, Mrs. Mabel B.,	Princeton, Me.
Hold, Ralph E.,	Oxford.
Holmes, Orlando D.,	North Billerica.
Hook, Homer M.,	Reading.
Howard, Wm.,	Northampton.
Hoxie, Asa S.,	Mattapoisett.
Hurlbutt, Horace C., Jr.,	Westport.
Jauncey, Wm.,	Groton.
Johnson, Robert B.,	Westborough.
Johnson, Roy L.,	Geneva, Ohio.
Keith, Willard F.,	Worcester.
Kellogg, Daniel F.,	Sheffield.
Kendall, Waldo W.,	Hadley.
Kenner, Edward M.,	Springfield.
Ladd, Charles M.,	Springfield.
Lataner, Harry,	Columbia, Conn.
Latham, John C.,	Boston.
Leary, Edward,	LaReville.
Lefevre, Oscar H.,	Jamaica Plain.
Le Geyt, Judson H.,	Barkhamsted, Conn.
Lerner, Philip A.,	Peru.
Lifter, Eli W.,	Hamilton.
Lindsley, Horace N.,	Orange, N. J.
Locke, John W.,	Salem.
Lord, John H.,	Maynard.
Lowney, Daniel W.,	Maynard.
MacDaniel, L. O.,	Ashfield.
MacDonald, Harold R.,	Amherst.
Martin, Orville D.,	Lunenburg.
Maxwell, Helen,	Brookline.
McCallum, John,	Northampton.
McIntyre, Clark,	Springfield.
McLaughlin, Edward,	Hingham.
McLearn, Robert,	Holliston.
McManus, Mark A.,	Lawrence.
Melrose, Fred,	Brookfield.
Mentor, Ramon B.,	Amherst.
Miller, Donald H.,	East Bridgewater.
Miller, Hugh,	Leeds.
Mitchell, David,	Springfield.
Morse, Clifford,	Northampton.
Murray, Harold,	Amherst.
Norris, Mrs. Elizabeth E.,	Amherst.
O'Leary, Francis,	Holliston.
Perry, Gardner, Jr.,	Dedham.

Priest, Donald L.,	Gleasondale.
Prouty, Ellis F.,	Amherst.
Reoch, Alfred,	Southborough.
Richardson, B. K.,	Middleton.
Richardson, Leroy M.,	Winchester.
Rowley, C. A.,	Paxton.
Russell, Helen W.,	Washington, Conn.
Rust, Phillip,	Northampton.
Samaniego, Luis,	Boston.
Savage, Arthur A.,	Philadelphia, Pa.
Scales, Mrs. Richmond P.,	Still River.
Scott, Lyndon,	Whately.
Seemann, Frieda,	Boston.
Shaw, Leslie,	Northampton.
Sheridan, Kathleen,	Winchester.
Smith, Martin M.,	White Valley.
Trowbridge, Virginia H.,	New Haven, Conn.
Tufts, Ellen,	Rockport.
Turner, Willis G.,	North Reading.
Vaughan, Carl,	Shrewsbury.
Ward, Harold,	Amherst.
Warfield, Howard L.,	Buckland.
Warren, Albert P.,	Groton.
Waterman, Fred T.,	Scituate.
Wesson, R. W.,	Grafton.
Wheeler, Sol,	Bantam, Conn.
Whitcomb, Howard R.,	Lunenburg.
Whitcomb, R. Oswald,	West Boylston.
Wilbur, W. A.,	Pittsfield.
Winter, Oliver A.,	West Roxbury.
Wright, Edna,	Springfield.
Wright, John B.,	Oxford.
Wright, Winthrop A.,	Billerica.

Summer School of Agriculture and Country Life.

Abbott, W. J.,	Danvers.
Adams, Ida M.,	Revere.
Agard, Mary C.,	South Hadley.
Allen, Mrs. Lois J.,	Amherst.
Andrew, Pauline M.,	North Adams.
Andrews, Gracy C.,	Amherst.
Archibald, Florence,	Lowell.
Armstrong, Mary C.,	Brooklyn, N. Y.
Austin, Fannie E.,	Leominster.
Austin, Idah R.,	Boston.
Bacon, Hazel,	Meriden, Conn.
Baker, Miss L. H.,	Newton Lower Falls.
Baker, Mrs. Warren S.,	Fort Landerdale, Fla.
Bartlett, Alice G.,	Worthington.
Bennett, Marion E.,	South Meriden, Conn.
Bird, Anna W.,	Wilmington, Del.
Brennan, E. Dorothy,	Melrose.
Broad, Gertrude F.,	Gloucester.
Butcher, Carolyn M.,	Roxbury.
Butcher, Gertrude,	Boston.
Caldwell, Saidee H.,	Bridgeport, Conn.
Campbell, Bertha M.,	East Windsor.
Capen, Elida M.,	Spencer.
Carlton, Louise E.,	Williamstown.
Carroll, Lillian M.,	Rockville, Conn.
Carver, Katharine,	Meriden, Conn.
Chase, Florence E.,	Sturbridge.
Cold, Bertha,	Yonkers, N. Y.

Comins, Esther M.,	Amherst.
Comins, Lucia,	Amherst.
Comins, Mildred L.,	Amherst.
Conway, Mary H.,	Dorchester.
Cook, Mary E.,	Conway.
Cooper, Caro L.,	Chelsea.
Coristine, W. H.,	Amherst.
Coristine, Mrs. W. H.,	Amherst.
Cotter, W. Francis,	Cambridge.
Crosskill, E. Gladys,	Wrentham.
Cummings, Mary F.,	Boston.
Currie, Mrs. Rose H.,	Cambridge.
Davis, Caroline M.,	Reading.
Derby, Dorothy,	Arlington.
Donovan, Nellie C.,	Turners Falls.
Dudgeon, H. N.,	Boston.
Dyer, Gertrude W.,	Provincetown.
Dykenan, Grace E.,	Chelsea.
Elwell, Hazel M.,	Keene, N. H.
Elwell, Susan W.,	Danvers.
Epstein, Anna,	Amherst.
Eustis, Florence M.,	Wellesley Hills.
Eustis, Helen,	Newton.
Fenstel, Edith S.,	South Hadley Falls.
Field, Florence E.,	Abington.
Fisher, Claribel P.,	Natick.
Fitz, Robert F.,	Beach Bluff.
Fitzgerald, A. J.,	Braintree.
Floersh, Miss M.,	Amherst.
Foster, Elliott O.,	Essex Junction, Vt.
French, Alice M.,	Lowell.
Gavin, Gertrude L.,	Roxbury.
Gavin, Madeline R.,	Roxbury.
Giles, Mrs. Lucy M.,	Westminster.
Gillett, Esther A.,	Tilton, N. H.
Gleason, Gertrude E.,	Newton Highlands.
Gleason, Mrs. Linette D.,	Newton Highlands.
Goessmann, Mary F.,	Amherst.
Goodale, Eula P.,	Fairhaven.
Grant, Editha M.,	Salem.
Grenier, Gladys,	Baltimore, Md.
Greninger, Louise C.,	Bridgeport, Conn.
Hagarty, Anne S.,	Dorchester.
Hammond, Grace de W.,	Haverhill.
Harding, Mrs. F. M.,	East Longmeadow.
Harding, Pearl M.,	East Longmeadow.
Harrington, Mabel A.,	North Adams.
Harris, Edna M.,	Meriden, Conn.
Harrison, Geo.,	New York, N. Y.
Hill, Amelia M.,	Brooklyn, N. Y.
Holman, Hilda,	Woburn, Mass.
Hore, Amy,	New York, N. Y.
Hovenden, Lena F.,	Newtonville.
Howe, Florence,	Leominster.
Hunt, Emma A.,	Framingham.
Ingraham, Ida M.,	Holyoke.
Jencks, Martha A.,	West Somerville.
Johnson, Phyllis M.,	Amherst.
Jones, Helen P.,	Waltham.
Jorgensen, George A.,	Waverley.
Josselyn, Abbie P.,	Allston.
Kalfur, Anna,	Richmond Hill, N. Y.
Keith, Lucy E.,	Gardner.
King, Alice W.,	Taunton.

Kingman, Miriam R.,	Somerville.
Labrovitz, Rose,	Amherst.
Lambert, Marjorie W.,	Milledgeville, Ga.
Lance, Eva E.,	South Meriden.
Lang, Elizabeth,	Woodhaven, N. Y.
Lathrop, Florence B.,	Reading.
Lawrence, Ethel F.,	Ashby.
Leete, Cora B.,	Springfield.
Levin, Ethel H.,	Amherst.
Lewis, Alice,	Meriden, Conn.
Lin, T. Y.,	Amherst.
Litch, John H.,	New London, N. H.
Loomis, Miss C. V.,	Winchester.
Lundin, Enor,	Quincy.
Ly, J. Usang,	West Philadelphia, Pa.
MacDougall, Mrs. A. F.,	Northampton.
Malone, Mary S.,	Wilmington, Del.
Middleton, George B.,	Winthrop.
Miller, Elizabeth,	Brookline.
Miller, Fred.,	Lynn.
Mitchell, Edward A.,	Coppahosie, Va.
Morse, Myrtie E.,	Wellesley.
Nagle, Elizabeth K.,	Brookline.
Nahmer, Miss C. D.,	Springfield.
Neale, W. G.,	Lynn.
Newell, Lena E.,	Bridgeport, Conn.
Newton, Georgianna M.,	Worcester.
Niles, Caleb H.,	East Lynn.
North, Miss L. V.,	Bradford.
Nye, Mary E.,	Hingham.
O'Brien, William S.,	Greenwich, Conn.
Osborne, Ethel B.,	Salem.
Pfaelzer, Howard R.,	Boston.
Pincus, Mrs. J. W.,	New York, N. Y.
Pond, Anna H.,	Milford.
Reed, Henry R.,	Arlington.
Reed, Julia,	Boston.
Reineche, Theo. G. W.,	Amherst.
Rhodes, Sara L.,	Brooklyn, N. Y.
Richardson, Alice S.,	Norwood.
Richardson, Ella L.,	Weston.
Robinson, Nathan H.,	Braintree.
Roche, Julia P.,	Salem.
Rogers, Geo. A.,	Jamaica, N. Y.
Rudd, Daisy P.,	Bennington, Vt.
Ruggli, Clara W.,	Cambridge.
Ryan, Bridget A.,	Sunderland.
Sanford, Mary E.,	Plainfield.
Shaddick, George,	Everett.
Simmons, Eva L.,	Bedford.
Smith, Jeannette,	Woburn.
Spokesfield, Mrs. E. M.,	Islington.
Stone, C. H.,	Brookline.
Stoughton Miss L. M.,	Winchester.
Sweeten, Mrs. Almira,	Baltimore, Md.
Swift, Mary E.,	Easton.
Temple, Myrtle G.,	North Adams.
Terry, Mrs. Julia S.,	Plainfield.
Thompson, A. S.,	Amherst.
Thompson, D. V.,	Lawrenceville, N. J.
Turner, Mrs. Mary,	South Meriden, Conn.
Van Auken, Susie M.,	Brockton.
Walker, Mary A.,	Hatfield.
Waterman, Edith G.,	Lowell.

Watson, Mary R.,	Plymouth.
Waugh, Dorothy,	Amherst.
Waugh, Esther,	Amherst.
Welch, Kate A.,	Worcester.
Welch, Mary J.,	Worcester.
West, Helen K.,	Brockton.
Wheeler, W. E.,	Pleasant Hill, Tenn.
White, Helena,	Amherst.
Whitney, Shirley,	Leominster.
Wilcox, Gertrude,	Mattapan.
Wilkins, Marion,	Newtonville.
Willis, Dora F.,	Ashfield.
Willis, Edith,	Brockton.
Wood, Annie D.,	Webster.
Wright, Alice L.,	New Haven, Conn.
Yost, Emma L.,	Meriden, Conn.

School for Rural Social Service.

Barker, George A.,	New Salem.
Blanchard, Miss S. A.,	Fitchburg.
Cardall, A. J.,	Orange.
Dalton, Mary E.,	Northfield.
Dwight, Clara B.,	South Amherst.
Eastman, Frances M.,	Amherst.
Estabrook, Mary V.,	Lunenburg.
Fletcher, Lizzie E.,	Three Rivers.
Garfield, Miss A. M.,	South Ashburnham.
Gleason, Elizabeth,	Burnside, Conn.
Hastings, Mrs. Mary E.,	Hadley.
Howlett, Cora,	South Amherst.
Hudson, Clara E.,	Plainfield.
Jackson, Ethel F.,	Springfield.
Johnson, Pearl M.,	Westfield.
Jostlyn, May L.,	Brier.
Kendall, Amelia,	Springfield.
Mack, Mary E. M.,	Wilbraham.
McConnell, Mary,	Quincy.
Merrill, James G.,	Lake Helen, Fla.
Moore, Bessie,	Northfield.
Moore, Harriet C.	Holden.
Moore, Ruth E.,	Northfield.
Powers, Eilene,	Leominster.
Powers, Elsie W.,	Leominster.
Reed, James P.,	Hadley.
Shaw, Ethel,	South Amherst.
Smith, Grace C.,	Springfield.
Snyder, Mabel C.	Plainfield.
Thacher, Olive W.,	Beverly.
Treworgy, Everett S.,	Ashby.
Van Der Hoop, Nannette C. W.,	Gay Head.
Van Der Hoop, Pauline,	Gay Head.
Wellington, Catharine J.,	Waltham.
White, Anna C.,	North Hadley.
Wilson, Joseph D.,	Philadelphia, Pa.
Woods, Mary B.,	Hatfield.

Apple Packing School.

Bean, Arthur H.,	Florence.
Burdett, A. E.,	Smiths Ferry.
Clark, George,	Tolland.
Lane, Wm. C.,	Cambridge.
Lathrop, B. M.,	Pittsfield.

Mason, W. B.,	Wrentham.
Mathers, Robert,	Williamsburg.
Wharton, Wm. P.,	Groton.

BEEKEEPERS' SCHOOL.

Bell, Mary,	Bay Side, Long Island, N. Y.
Bellamy, Mrs. John,	Dorchester.
Cole, E. Frances,	Dedham.
Coristine, W. H.,	Amherst.
Floersh, Miss M.,	Amherst.
Russell, Helen W.,	Washington, Conn.
Scott, Russell,	East Alstead, N. H.
Sheridan, Kathleen,	Winchester.
Stanley, Mary B.,	West Hartford, Conn.
Trowbridge, Virginia H.,	New Haven, Conn.

ADDENDUM TO PAGE 31.

Additional entrance credit in agriculture may be allowed in individual cases, if recommended and authorized by the Division of Agriculture of the college. Early application to the head of the Division is advisable, and schools likely to present such candidates are urged to correspond with this officer at once, that the necessary investigation and inspection may be made in time.

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THE M. A. C. BULLETIN

AMHERST, MASS.

VOLUME IX | SEPTEMBER, 1917 | NUMBER 5

MASSACHUSETTS AGRICULTURAL COLLEGE

Supplement to the Catalog

Published six times a year by the Massachusetts Agricultural College.
January, February, March, May, September, October.
Entered as second-class matter at the Post-office, Amherst, Mass.

This pamphlet announces the calendar for the college year 1917—1918, new courses for regular students, rules governing the admission of unclassified students and certain courses prepared particularly for them.

Kenyon L. Butterfield, President,
Amherst, Mass.

September 25, 1917.

CALENDAR 1917–1918.

1917

Oct. 10. Wednesday, 1:30 p. m. Fall Term Begins, Chapel.

Nov. 28. Wednesday, 12:30 p. m.—Friday, Nov. 30, 1:30 p. m., Thanksgiving Recess.

Dec. 15. Saturday, 12:30 p. m. Fall Term Ends.

Dec. 17. Monday, 7:30 a. m. Winter Term Begins.

Dec. 22. Saturday, 12:30 p. m. Christmas Recess Begins.

Dec. 31. Monday, 1:30 p. m. Christmas Recess Ends.

1918

Feb. 23. Saturday, 12:30 p. m. Winter Term Ends.

Feb. 25. Monday, 7:30 a. m. Spring Term Begins.

April 26. Friday, 5:30 p. m. Spring Term Ends.

April 27—29. Saturday—Monday. Commencement.

DEPARTMENT OF MARKET GARDENING.

50. **II.** Offered in the second term instead of the third term.

51. **III.** Continuation of 50, II, for Juniors; 3 class hours, two 2-hour laboratory periods, credit 5.

Assistant Professor A. S. THOMSON.

DEPARTMENT OF ZOOLOGY AND GEOLOGY.

Additional Courses.

Conservational and Economic Zoology:—

51. **II.** CONSERVATIONAL ZOOLOGY. — For Juniors; Seniors may elect. This course aims to bring before the student the great public problems of the conservation of wild life, especially the natural fauna of the state, and the more complete utilization of various forms of animal life on the farm projects. 2 class hours; one 2-hour laboratory period, credit 3.

Dr. BALL.

76. **II.** ECONOMIC ZOOLOGY.—*Birds in their Relations to Crops, Insects and Man.*—For Juniors and Seniors, Sophomores may elect. This course deals with the broad economic relations of the birds. The student is taught to know the birds, and their migrations and distribution.
1 class hour, two 2-hour periods, credit 3. Dr. BALL.

77. **III.** ECONOMIC ZOOLOGY.—*Birds in their Relations to Crops, Insects and Man.*—For Juniors and Seniors, Sophomores may elect. In this course the student reviews what is known of the specific food habits of our most important economic birds, carries his studies into the field, and gets an intimate acquaintance with our Massachusetts birds and their habits in relation to crops, orchards, woodlands and to each other. 2 class hours, one 2-hour laboratory period, credit 3. Dr. BALL.

DEPARTMENT OF AGRICULTURAL ECONOMICS.

New Courses and Adjustment of Present Courses.

78. **III.** AGRICULTURAL CREDIT FACILITIES.—For Seniors and Juniors. The legitimate use of credit in the production, storing and marketing of agricultural products. A brief survey of the development of credit institutions. National and state rural credit laws. Farm Land Banks, credit associations, and other means of securing personal credit. The topics will be discussed from the standpoints of dealers in agricultural produce, the landowning farmer, the tenant, and the farm laborer ; special attention will be given to the credit needs of the college graduate. 2 class hours, credit 2. Mr. WILKINSON.

51. HISTORY OF AGRICULTURE, now scheduled in the first term, will be scheduled in the third term.

77. PROBLEMS, now scheduled in the third term, will be transferred to the first term, and be omitted in 1917—18.

75. MARKETING.—This course will be offered in the fall term of 1917, but thereafter will be transferred to the third term, when it will become a Junior course numbered 53.

Special Supervision Courses Offered in 1917-18.

These courses will be open to Juniors and Seniors for the purpose of more adequately preparing them for supervision work for next season. Each will consist of three lecture periods per week with a credit of 3. Any laboratory work required will be by arrangement.

First Term :

CONTROL OF INSECT PESTS : 2 weeks.

A thoroughly practical course dealing briefly with the essential points in the life history of the most important insects, with a full discussion of the best methods of controlling the same. There will be included a study of spraying apparatus and spraying materials.

Professor FERNALD.

MARKET GARDENING : 6 weeks.

1. Identification of common vegetables by seeds, by roots and foliage, about twenty to twenty-five species, including one to four varieties in each.
2. Technical demonstration and practice in preparing seed beds.
3. Technical demonstration and practice in planting seeds, bulbs, cuttings, and transplants.
4. Technical demonstration and practice in preparing germination boxes and raising young plants.
5. Technical demonstration and practice in cultivation.
6. Planning home and market gardens.
7. Study of the preparation for market.

Assistant Professor A. S. THOMSON.

Second Term :

Courses for Agricultural Club Supervisors : 2 weeks.

1. The community and permanent organization of agricultural clubs.
2. The community and temporary organization of agricultural clubs.
3. Junior extension work—its history and purpose.
4. Methods of organization of community club work.
5. Methods of organization of club work.
6. Lectures on pig and poultry club work.

Professor Hart.

Soils.—6 weeks. Types and general characteristics, adaptability for different crops ; manures, composition of fertilizers, methods of application, etc,: preparing soil for gardens, tillage implements, control of obnoxious weeds and grasses.

Associate Professor Beaumont.

Third Term :

Diseases of Garden Crops.—2 weeks. Consideration of the more common diseases of garden vegetables, with opportunity in the laboratory to become familiar with their appearance. Three hours a week for 2 weeks. Department of Botany.

Animal Husbandry.—3 weeks. Lectures will be given on the feeding, breeding, and management of all classes of livestock, with special emphasis upon the practical questions of the farmer and breeder.

Professor McNutt.

Preservation of Fruits and Vegetables.—3 weeks. Methods of canning, dehydrating, evaporating, storage ; when and with what crops to use the different methods ; equipment for home and community plants ; the organization of community enterprises.

Associate Professor Chenoweth.

BEEKEEPING.

The description of the courses now offered in Beekeeping was inadvertently omitted from the catalog of 1916–17. The following courses are offered :

60. Beekeeping.—Juniors ; Seniors may elect. This course comprises a general consideration of the biology of the honey bee and the elements of practical beekeeping. Some topics covered are : life history, general behavior and instincts, structure, products, relations of bees to plants, the honey flora. The course aims particularly to afford first-hand, practical experience with bees, to the end of enabling their proper maintenance for any purpose, horticultural, educational or apicultural. Bee diseases, a thorough understanding of which is fundamental, are emphasized. So far as possible, the work is made individual in constructing materials and apparatus and in the manipulation of bees. 3 lectures, two 2-hour laboratory periods ; credit 5. Associate Professor Gates.

80. ADVANCED BEEKEEPING.—Seniors; Juniors may elect. This course deals with the advanced and special problems of the beekeeper. Besides considering those difficulties which at present confront the industry, subjects necessarily of limited treatment in the previous course are expanded for the development of particular technique and manipulation. Apiary management, including the principles of queen rearing, is practiced. The course should further qualify for apicultural instruction and inspection service, affording familiarity with the special literature and methods needed in investigation and research. The policy of individual instruction is continued in so far as practicable. Prerequisite, Course 60; 2 lectures, one 2-hour laboratory period; credit 3.

Associate Professor GATES.

WORK FOR WOMEN TO BE SUBSTITUTED FOR WORK IN MILITARY SCIENCE.

1. **I.** ELEMENTARY MICROBIOLOGY.—For Freshmen Women. The course will be devoted to the various types of microorganisms, their distribution in nature and their characterization. Such methods as are essential for examination, manipulation and culturing will be studied and employed. 6 laboratory periods, credit 3. Dr. ITANO and Mr. RAY.

In place of

Military	1,	Tactics	Fall Term, Freshmen.
Military	4,	Drill	

3. **III.** ELEMENTARY MICROBIOLOGY FOR WOMEN.—Continuation of No. 1. 4 laboratory periods, credit 2. Dr. ITANO and Mr. RAY.

In place of

Military	3,	Tactics	Spring Term, Freshmen.
Military	6,	Drill,	

25. **I.** PERSONAL HYGIENE.—For Sophomore Women. Such subjects as the hygiene of the mouth and teeth, the gastro-intestinal tract, food, the skin, respiration apparatus, ear, eye and nervous system are reviewed. The value of bathing, clothing, physical exercise, etc., are considered. Attention will be given to emergencies, accidents of "first aid" and such other matters as usually fall within this category. 2 class hours, credit 2.

Professor MARSHALL.

In place of

Military	27,	Tactics	Fall Term, Sophomores.
Military	28,	Drill	

27. **III.** SANITARY SCIENCE.—For Sophomore Women. The usual topics of sanitary science, as ventilation, heating, plumbing, water supply, sewage disposal, food control and communicable diseases, will be treated wholly from the standpoint of individual and public health control. 2 class hours, credit 2. Professor MARSHALL.

In place of

Military	27	Spring Term, Sophomores.
Military	30	

Work in physical education, conducted by Mrs. Hicks, will be required 3 hours per week during the year.

ADDITIONAL OPPORTUNITIES FOR GRADUATE WORK.

The degree of Master of Landscape Architecture is authorized in connection with graduate work offered in the Department of Landscape Gardening, and for this degree there is required one year's experience in addition to the period of one and one-half years in residence.

The degree of Doctor of Philosophy is authorized for major work in the Department of Agricultural Economics.

The degree of Doctor of Philosophy is authorized for major work in the Department of Rural Sociology.

RULES GOVERNING THE ADMISSION OF UNCLASSIFIED STUDENTS.

Students not candidates for a degree (unclassified students) are admitted under the following provisions:—

1. All unclassified students are subject to the supervision of a special committee.

2. No applicant under 18 years of age will be admitted as an unclassified student.

3. No entrance examination is required, but applicants must bring certificates showing that they have finished a four-year high school course or its equivalent, and furnish satisfactory testimonials as to moral character.

4. No student of this or any other institution who has not done efficient work therein shall be permitted to register as an unclassified student.

5. Each unclassified student must take from the regular technical elective courses, and necessary prerequisites, a minimum of twelve credit hours a week.

6. In order to be admitted to any course, an unclassified student must have had all prerequisite subjects for that course.

7. Every unclassified student must do all the work of the courses elected, and take all examinations therein. In order to pass such courses he must attain a grade of at least 60 per cent. An unclassified student who passes in less than 60 per cent of his work will be dropped from college.

8. Any unclassified student may be dropped from college at any time if his presence in any class is undesirable or his work is unsatisfactory; and no unclassified student will be allowed to remain in college more than six terms without the special permission of the faculty.

9. No unclassified student shall be allowed to participate in any intercollegiate contests.

10. Unclassified students are subject to the general regulations applying to classified students.

11. Every unclassified student should clearly understand that before any application for transfer to the regular registration for the B. Sc. degree will be considered by the Registrar, he must present all entrance credits either by certificate or by examination in the same way as is required of a student who enters regularly.

SPECIAL COURSES FOR UNCLASSIFIED STUDENTS.

Unclassified students will enroll in these courses instead of courses bearing similar numbers in the catalog, and which are offered to regular students.

Chemistry.

7. **I.** Elementary Agricultural Chemistry.—Unclassified. This is a special course for unclassified students endeavoring to give in one term the essential facts and ideas of general chemistry and the chemistry of soils and fertilizers so that the student may be able to take up similar special courses in Agronomy. The course will consist of a brief study of important elements and compounds, followed by a special study of the chemistry of soils and fertilizers. Textbook, Tottingham & Ince, "Chemistry of the Farm and Home." This will be supplemented by laboratory notes. 4 class hours, one 2-hour laboratory period, credit 5.

Professor Chamberlain.

Agronomy.

2. **II.** Soil Fertility. Unclassified. A study of soils and their properties, manures, fertilizers and soil amendments. The principles and factors of soil management will be considered, together with the economical and practical means of improving and maintaining soil fertility. 3 class hours, one 2-hour laboratory period, credit 4.

Associate Professor Beaumont.

Public Document No. 31

TWENTY-NINTH ANNUAL REPORT

OF THE

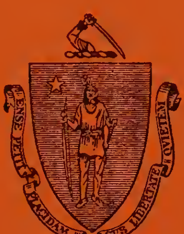
MASSACHUSETTS AGRICULTURAL EXPERIMENT STATION.

PARTS I. AND II.,

BEING PARTS III. AND IV. OF THE FIFTY-FOURTH ANNUAL REPORT OF THE MASSACHUSETTS AGRICULTURAL COLLEGE.

JANUARY, 1917.

ENDING THE THIRTY-FOURTH YEAR FROM THE FOUNDING OF THE STATE AGRICULTURAL EXPERIMENT STATION.



BOSTON:
WRIGHT & POTTER PRINTING CO., STATE PRINTERS,
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1917.

Publication of this Document
approved by the
Supervisor of Administration.

TWENTY-NINTH ANNUAL REPORT

OF THE

MASSACHUSETTS AGRICULTURAL EXPERIMENT STATION.

PART I.

REPORT OF THE DIRECTOR AND OTHER OFFICERS.

PART II.

DETAILED REPORT OF THE EXPERIMENT STATION.

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Massachusetts Agricultural Experiment Station.

OFFICERS AND STAFF.

STATION STAFF.

Administration.

William P. Brooks, Ph.D., *Director*.
Joseph B. Lindsey, Ph.D., *Vice-Director*.
Fred C. Kenney, *Treasurer*.
Charles R. Green, B.Agr., *Librarian*.
Mrs. Lucia G. Church, *Clerk*.
Miss F. Ethel Felton, A.B., *Clerk*.

Agricultural Economics.

Alexander E. Cance, Ph.D., *In Charge of Department*.

Agriculture.

William P. Brooks, Ph.D., *Agriculturist*.
Henry J. Franklin, Ph.D., *In Charge of Cranberry Investigations*.
Edwin F. Gaskill, B.Sc., *Assistant Agriculturist*.
Robert L. Coffin, *Assistant*.

Botany.

A. Vincent Osmun, M.Sc., *Botanist*.
George H. Chapman, Ph.D., *Research Physiologist*.
Paul J. Anderson, Ph.D., *Associate Plant Pathologist*.
Orton L. Clark, B.Sc., *Assistant Plant Physiologist*.
Miss Grace B. Nutting, Ph.B., *Clerk*.

Plant and Animal Chemistry.

Joseph B. Lindsey, Ph.D., *Chemist*.
Edward B. Holland, Ph.D., *Associate Chemist in Charge (Research Division)*.
Fred W. Morse, M.Sc., *Research Chemist*.
Henri D. Haskins, B.Sc., *Chemist in Charge (Fertilizer Division)*.
Philip H. Smith, M.Sc., *Chemist in Charge (Feed and Dairy Division)*.
Lewell S. Walker, B.Sc., *Assistant Chemist*.
Carleton P. Jones, M.Sc., *Assistant Chemist*.

Plant and Animal Chemistry — *Con.*	Carlos L. Beals, M.Sc., *Assistant Chemist.* James P. Buckley, Jr., *Assistant Chemist.* Windom A. Allen, B.Sc., *Assistant Chemist.* John B. Smith, B.Sc., *Assistant Chemist.* James T. Howard, *Inspector.* Harry L. Allen, *Assistant in Laboratory.* James R. Alcock, *Assistant in Animal Nutrition.* Miss Alice M. Howard, *Clerk.* Miss Rebecca L. Mellor, *Clerk.*
Entomology.	Henry T. Fernald, Ph.D., *Entomologist.* Burton N. Gates, Ph.D., *Apiarist.* Arthur I. Bourne, A.B., *Assistant Entomologist.* Stuart C. Vinal, B.Sc., *Graduate Assistant.* Miss Bridie E. O'Donnell, *Clerk.*
Horticulture.	Frank A. Waugh, M.Sc., *Horticulturist.* Fred C. Sears, M.Sc., *Pomologist.* Jacob K. Shaw, Ph.D., *Research Pomologist.* Harold F. Tompson, B.Sc., *Market Gardener.* Robert P. Armstrong, M.Sc., *Graduate Assistant.* Miss Eleanor Barker, *Clerk.*
Meteorology.	John E. Ostrander, A.M., C.E., *Meteorologist.* James S. Sims, *Observer.*
Microbiology.	Charles E. Marshall, Ph.D., *In Charge of Department.* F. H. Hesselink van Suchtelen, Ph.D., *Associate Professor of Microbiology.*
Poultry Husbandry.	John C. Graham, B.Sc., *In Charge of Department.* Hubert D. Goodale, Ph.D., *Research Biologist.* Lloyd L. Stewart, B.Sc., *Graduate Assistant.* Miss Marcella C. Curry, B.Sc., *Clerk.*
Veterinary Science.	James B. Paige, B.Sc., D.V.S., *Veterinarian.* G. Edward Gage, Ph.D., *Associate Professor of Animal Pathology.* John B. Lentz, V.M.D., *Assistant.* Alfred C. Edwards, V.M.D., *Assistant.*

REPORT OF THE DIRECTOR.

WM. P. BROOKS.

ADMINISTRATION.

Station Staff.

The working force of the experiment station during the past year has suffered two especially serious losses in the resignation, effective October 1, of Dr. George E. Stone of the botany department, and that of Mr. A. B. Sturtevant of the veterinary department, effective December 1. Both these men had demonstrated much ability as investigators.

Dr. Stone had been at the head of the department of botany since 1895, and from the first had been exceptionally active as an investigator. His capacity for close observation and accurate deduction from observed facts was quite unusual, his mind exceptionally active and his inventive genius great. These qualities upon a foundation of thorough training and long experience, and with the capacity which he possessed of arousing the interest and enlisting the co-operation of advanced students, made Dr. Stone, in health, a highly fruitful investigator. That he found it necessary to tender his resignation is much to be regretted.

Mr. Sturtevant, although connected with the station only a little more than a year, had already shown much talent as an investigator, and his work had been characterized by such industry and enthusiasm that his resignation to accept a similar position for the investigation of bee diseases in the Bureau of Entomology of the United States Department of Agriculture creates a vacancy which it will be difficult to fill. The course followed by the Federal department practically means that a fundamental, scientific investigation well under way in this station is brought to a premature end so far as we are concerned, for the work which has been done is unique, and Dr.

Phillips, in charge of the investigations in bee culture in Washington, himself stated that he knew of no other man qualified for such work. The experiment station director, unable to compete financially with the Federal department, finds such an experience extremely discouraging.

Prof. A. V. Osmun, who has been connected with the department of botany in the college since 1905 and who during nearly two years had been in administrative charge, was made head of the department on October 1. Professor Osmun's knowledge of the fungi associated with pathological conditions, and of the various plant diseases caused by them, strengthens the department in a line in which it was relatively weak.

The assignment of Paul J. Anderson, Ph.D., connected with the teaching staff since Jan. 1, 1915, to part-time service in the station still further strengthens the department along this line.

Orton L. Clark, B.Sc., one of our specialists in plant physiology, was made assistant professor of botany at the beginning of the college year, and from that date has given only one-half time to station work.

R. W. Ruprecht, Ph.D., an assistant in the chemical department since 1911, resigned on December 1 to accept a far more lucrative position as chemist in a company manufacturing fertilizers. Mr. Ruprecht had shown rather exceptional ambition and industry. His methods indicated considerable capacity of initiative, and he had accomplished highly creditable original work.

The other changes in staff require no special comment except to point out that practically all resignations have been due to the offer of higher salaries in other quarters. The following is a complete statement of the changes.

Resignations.

George E. Stone, Ph.D., Vegetable Physiologist and Pathologist.
Miss Beryl H. Paige, A.B., Assistant in Veterinary Science.
Charles W. Davis, B.Sc., Assistant Chemist.
Rudolf W. Ruprecht, Ph.D., Assistant Chemist.
Arnold P. Sturtevant, A.B., Assistant in Veterinary Science.
W. T. Payne, B.Sc., Graduate Assistant, Industrial Tests.
Miss Mary L. Chase, Graduate Assistant, Industrial Tests.

Donald White, B.Sc., Graduate Assistant in Poultry Husbandry.
Miss Gladys E. Russell, A.B., Clerk, Division of Horticulture.
Miss Jessie V. Crocker, Clerk, Department of Botany.

To Instructional Staff for Part-time Only.

Orton L. Clark, B.Sc., Assistant Professor of Botany.

Appointments.

J. B. Lentz, V.M.D., Assistant in Veterinary Science.
W. A. Allen, B.Sc., Assistant Chemist.
John B. Smith, B.Sc., Assistant Chemist.
Alfred C. Edwards, V.M.D., Assistant in Veterinary Science (half time on the instructional staff).
Miss Mary L. Chase, Graduate Assistant, Industrial Tests.
S. G. Mutkekar, B.Agr., Graduate Assistant, Industrial Tests.
Lloyd L. Stewart, B.Sc., Graduate Assistant, Poultry Husbandry.
R. C. Avery, B.Sc., Graduate Assistant, Industrial Tests.
Miss Grace B. Nutting, Ph.B., Clerk, Department of Botany.

From Instructional Staff for Part-time Only.

P. J. Anderson, Ph.D., Associate Plant Pathologist.
Miss Eleanor Barker, Clerk, Department of Horticulture.

Leaves of Absence.

F. C. Sears, M.Sc., Pomologist, from July 1, 1916, to Dec. 31, 1916.
Rudolf W. Ruprecht, Ph.D., Assistant Chemist, from Oct. 1, 1915, to June 30, 1916.

Maintenance.

The sources of revenue upon which the experiment station depends have been the same during the past year as in all recent years. The amount for general expenses from the State, in accordance with the provision of the Acts of 1912, has been $5,000 greater than in the previous fiscal year. The receipts from the sales of fruit from Graves' orchard have been exceptionally large. There has been a further decline, due primarily to the influence of the European war, in the receipts for analysis fees under the fertilizer law. This in round numbers amounts to $700. The total revenues are shown in the following table: —

Total Revenue for the Fiscal Year, Dec. 1, 1915, to Nov. 30, 1916.

State appropriation,	$30,000 00
Federal appropriations: —	
Hatch fund,	15,000 00
Adams fund,	15,000 00
Agricultural department, sales and labor,	5,075 29
Chemical department, sales, cow testing and analytical work,	11,999 93
Miscellaneous receipts from various departments,	162 54
Blood tests,	519 50
Fertilizer law, analysis fees,	9,400 00
Feed law, State appropriation,	6,000 00
Cranberry substation: —	
Sale of fruit,	2,643 45
Meteorological observations, etc.,	126 67
Miscellaneous,	1 00
Graves' orchard: —	
Sale of fruit,	1,031 64
Sale of surplus barrels,	99 51
Tillson farm: —	
Rent,	225 00
Sale of fruit,	97 08
Farm produce,	1 88
Total,	$97,383 49

The aggregate total revenue exceeds the aggregate for last year to the amount of $9,494.81. The total required in the execution of the feed and fertilizer laws amounted to $17,067.88. These expenditures in detail are shown in subsequent pages. The total current revenue available for general administration, routine work and investigation, therefore, amounted to $80,315.61. Of this total about $12,475 is used in meeting the costs of cow testing, in interdepartment labor and for other routine analytical work. The amount actually available for investigation, therefore, is less by this figure than the total just stated, or about $67,840.

The treasurer's report in full will be found on pages 41*a* and 42*a*.

Special Appropriations.

Market-garden Station. — The fact that the Boston Market Gardeners' Association was endeavoring to secure the passage in the 1916 Legislature of a bill appropriating money for the

purchase of land, erection of buildings and purchase of equipment for a market-garden station, and providing also for its annual support, was referred to in my last annual report. This movement was only in part successful. Instead of the $20,000 asked for land, buildings and equipment only $8,000 was granted, and no provision was made for the annual support of the work. With the sum available 12 acres of well-located land in Lexington of apparently highly suitable quality have been purchased, and something has been accomplished in the direction of preparing it for use. There are no buildings on the property, and relatively little can be done until these are provided and provision made for annual support. An effort to secure the needed appropriation will be made in the legislative session of 1917 by the Boston Market Gardeners' Association.

Tobacco Investigation. — The tobacco growers of the valley, as stated in my last annual report, endeavored to secure in the Legislature of 1916 an appropriation of $2,000 to be expended at the station in the investigation of problems connected with the production of tobacco. This movement was not entirely successful, but a substitute resolve, designed to meet in part this need and at the same time partially meeting the request of the college for an appropriation for miscellaneous improvements and new equipment, was enacted. Out of the sum thus provided about $400 was made available to cover the cost of putting concrete beds into the greenhouse of the department of botany for use in the experiments with tobacco, and the purchase of apparatus needed for the experimental work with the crop. The expenditure of this small sum of money has made it possible simply to make a beginning. The tobacco growers have already initiated a movement to secure a special appropriation for this work in the 1917 session of the Legislature.

Publication.

The operation of the law relative to station publications as amended in 1914 continues to be highly satisfactory from every point of view. Published matter is more promptly available for distribution and in better form, and at the same time a large saving in the cost of editions is possible by the discretionary power given to the director to fix the number of copies of

bulletins printed. The financial outcome as affecting the State treasury is shown in the table. For a full understanding of the results it is necessary to point out that under the amended law the station is entirely relieved of expenditure for bulletins, — an expenditure which in the last year under the old law amounted to rather more than $700, as pointed out in the twenty-seventh annual report.

Comparison of Cost of publishing Bulletins and Reports.

	1913.	1914.	1915.	1916.
Cost to station,	$722 48	-	-	-
Cost to State,	2,689 28	$1,765 17	$1,872 81	$2,112 41[1]

[1] Includes $239.60, the cost of the report of the cranberry substation, which will be bound with the 1917 report.

During the past year a change in policy affecting the publication of circulars has gone into effect. Under the new plan circulars, except such as relate to the administrative work of the experiment station, are published by the extension service of the college, even although the contents may relate almost exclusively to the results of station investigations. This change appears to be in line with our general policy as regards the division of work between different divisions of the institution, since the extension service is the branch of the institution designed especially to carry its message to the public. Attention should be called to the fact that the principal use of extension circulars, as is the case with experiment station circulars, is as a means of giving information in connection with correspondence and inquiries. The circulars are not sent to a mailing list, and they will be used as well by the experiment station in connection with correspondence as by the extension service, though published by the latter.

Annual Report.

Twenty-eighth annual report: —
Part I. Report of the Director and Other Officers; 72 pages.
Part II. Detailed Report of the Experiment Station; 185 pages (being Bulletins Nos. 163–167).
Combined Contents and Index, Parts I. and II.; 16 pages.

Bulletins.

No. 168. Report of Cranberry Substation for 1915, by H. J. Franklin; 48 pages.
No. 169. Connecticut Valley Onion Supply and Distribution, by Alexander E. Cance, William L. Machmer and Frederick W. Read; 74 pages.
No. 170. Shade Trees, Characteristics, Adaptation, Diseases and Care, by George E. Stone; 190 pages.
No. 171. A Chemical Study of the Asparagus Plant, by F. W. Morse; 32 pages.
No. 172. Experiments in keeping Asparagus after Cutting, by F. W. Morse; 11 pages.

Bulletins, Control Series.

No. 5. Inspection of Commercial Feedstuffs, by P. H. Smith; 69 pages.
No. 6. Inspection of Commercial Fertilizers, by H. D. Haskins; 93 pages.

Circulars.

No. 59. The Use of Fertilizers in 1916, by William P. Brooks; 8 pages.
No. 60. Suggestions for the Use of Fertilizers for Tobacco and Onions for 1916, by H. D. Haskins; 4 pages.
No. 61. Cutworms, by H. T. Fernald; 2 pages.
No. 62. Beet Residues for Farm Stock, by J. B. Lindsey; 7 pages.
No. 63. Balanced Rations for Dairy Stock, by J. B. Lindsey, 8 pages.
No. 64. Co-operative Soil Studies by the Agricultural Experiment Station and the Extension Service of the Massachusetts Agricultural College, by F. W. Morse; 3 pages.
No. 65. Campaign to eliminate Bacillary White Diarrhœa; 1 page.
No. 66. Poultry Farm Disinfection, by James B. Paige; 4 pages.

Miscellaneous.

Guide to Plots — Plans and Data relating to the Field Plots of the Agricultural Department of the Massachusetts Agricultural Experiment Station; 20 pages.

Meteorological Reports.

Twelve numbers, 4 pages each.

The total number of copies of general reports and bulletins issued during the last fiscal year was 61,700. In addition, 5,400 meteorological bulletins were printed, 3000 copies of the guide to plots, and 28,300 copies of circulars, making a grand total of 98,400 copies of publications issued during the year.

Mailing Lists.

A complete revision of our general and of several of our special Massachusetts mailing lists has been completed during the year. The last previous revision was completed in 1914. The changes in every revision which have been made necessary by deaths, removals and other causes are surprisingly numerous. The result of our last revision is a net loss of 1,398 names as compared with the number one year ago. This, however, will be much more than offset by the addition soon to be made of the names of several thousand poultry keepers which have been listed by the poultry department. Details will be found in the following table: —

Residents of Massachusetts (general),	11,411
Residents of other States (general),	1,296
Residents of other States (general and technical),	1,093
Exchange,	229
Massachusetts libraries,	190
Out-of-State libraries,	237
Massachusetts agricultural schools and instructors,	101
Massachusetts farm bureaus and county agents,	16
Massachusetts Agricultural College and Experiment Station staffs.	109
Beekeepers,	3,857
Newspapers,	427
Cranberry growers,	1,340
Meteorological,	391
Feed manufacturers and dealers,	246
Fertilizer manufacturers and dealers,	81
Greenhouse vegetable growers,	1,850
Onion growers,	107
Massachusetts florists,	1,100
Miscellaneous special lists,	187
United States Department of Agriculture, official list,	3,633[1]
Total,	27,901[2]

[1] Publications are not, as a rule, sent to all on this list, but only to directors, libraries and specialists likely to be interested.

[2] Of this total, under different lists are included 280 foreign addresses.

Essentials for Needed Development.

Some of the more pressing and immediate needs of the station have been mentioned and briefly discussed in recent reports. A considerable number of these have not yet been met or have been met only in part. For this reason, and also because it takes a longer look ahead, it seems desirable to present here in its entirety a statement covering the more essential requirements as they are now apprehended for what may be regarded as the normal development of the station work for the next five years, which was prepared at the suggestion of the Special Commission on Agricultural Education at the Massachusetts Agricultural College and the Development of the Agricultural Resources of the Commonwealth. The inclusion of this statement involves a second reference to two matters referred to in earlier pages, viz., provision for a substation in market gardening and the support of its work, and an annual grant for tobacco investigations. The needs of the experiment station as presented in the statement to the commission follow: —

1. *Land needed.*

Tillson Farm. — Area, nearly 80 acres; cost as agreed in contract, $5,000.

This farm is now leased and the lease still has six years to run. It is greatly needed for use in connection with a number of important lines of investigation, some of the more important of which are experiments in use of manures and fertilizers, plant breeding, pasture improvement, crop rotation and pork production. This farm is located about three-quarters of a mile from the station center. On it there are only two buildings, — a very small, cheap cottage occupied by a Polish laborer, and a tobacco shed. It will not be possible, except at very great disadvantage, to carry on such experimental work as is pressing until buildings are provided. Clearly, it will be bad business policy to erect buildings upon property which we are not certain some time to own. The purchase price agreed upon is low, hardly equal to the normal market value of such property in Amherst. To fail to close the option would, accordingly, seem very shortsighted policy; and, since the property cannot be used to advantage

previous to the erection of buildings, purchase at a very early date seems highly desirable.

Tuxbury Land. — Total area about 30 acres, 18 of which are improved land and about 12 acres sprout land; estimated cost, $12,000.

The experiment station now leases 18 acres of this land, and a large part of this is planted to apple orchard. The experiments in progress are of fundamental importance, and it is already apparent that they cannot be completed within the period which the lease still has to run, — about fifteen years. None of the trees have been permanently set more than two years, and a large part of them were set last spring. They will barely have reached the period of most profitable production at the time of the expiration of the lease. It would be a great misfortune should it be terminated at that time; and, since the purchase price is certain to increase, and since ultimate ownership is highly desirable, it seems the part of wisdom to acquire the property at as early a date as possible.

A Poultry Farm. — Area desired, about 60 acres; estimated cost, $8,000.

The poultry department is engaged in breeding experiments of such a character as make necessary the rearing of very large numbers of fowls. These cannot be satisfactorily raised except under conditions where free range over uncontaminated areas is possible. The area at present available is far too small. We have for some years been compelled to lease land on which to raise young stock. This policy is quite unsatisfactory both on account of the fact that we must frequently go a much greater distance than is at all convenient, and because the prices which must be paid are high.

Summary.

Tillson farm,	$5,000
Tuxbury land,	12,000
Poultry farm,	8,000
Total,	$25,000

2. Buildings needed.

Tillson Farm. — Dwelling house for man in local charge, \$4,000; barn and outbuildings, \$6,000.

The necessity for buildings on this farm has been referred to in discussing the urgency of early purchase. Experimental work can be carried on only where we have large storage room, where different materials and the product of different plots can be kept separate, and where we have facilities for weighing, sampling, etc. A barn of large size and specially equipped, and a number of outbuildings, will clearly be necessary; and a house for the man in local charge is also, if not an absolute necessity, at least highly desirable, as the farm is at such a distance from the present center that the needed oversight, which must be close and constant in experimental work, will be exceedingly difficult without.

Poultry Department. — Building additions in present location, \$3,500; buildings required in case a farm for poultry experimental work is purchased, \$10,000.

It will be readily understood that experimental work is impossible without building accommodations specially equipped and far larger than are required in commercial work. Comparisons are impossible without such accommodations. Poultry interests a very large proportion of our population, and in the aggregate our poultry industry is of very great importance. That we do not now probably produce more than about one-fifth of the poultry products used in the State emphasizes in a striking way the fact that everything possible should be done to encourage the growth of the industry. Professor Graham estimates that the total value of the poultry products of the State is now between \$7,000,000 and \$8,000,000 annually; and the amount consumed in the neighborhood of \$45,000,000 worth.

Cranberry Substation. — An addition to the building of the cranberry substation for extension of the work; estimated cost, \$500.

Summary.

Tillson farm: —	
House,	\$4,000
Barn and outbuildings,	6,000

Poultry department: —	
Buildings in present location,	$3,500
Buildings on new farm when acquired,	10,000
Cranberry substation: —	
Addition,	500

Market-garden Staiion. — Four greenhouses, dwelling house, office, barn, sheds and equipment, $24,450.

The Legislature has appropriated money for the purchase of land for a market-garden station. Vegetable forcing under glass constitutes a very prominent branch of the market-garden industry in this State, and it is the branch of that industry which perhaps more than any other is in need of careful experimental work. At least four houses should be provided at as early a date as possible.

Attention is called further to the fact that the development of the institution already indicates the desirability, and will comparatively soon make it practically necessary, to move the buildings now used for feeding experiments in animal husbandry. These buildings will also need enlargement, but, as it is not anticipated that removal will be necessary within the next five years, no financial estimate is presented.

The head of the department of meteorology calls attention to the fact that the tower in South College, in which the meteorological observatory is now located, is becoming unsafe on account of the condition of the mortar. He urges that the fact should be kept in mind that a new tower should be provided, and suggests that it be made a part of some building to be erected in the future. It is clearly impossible to present an estimate.

3. *Increases needed for Annual Support.*

Work in market gardening (annually),	$6,500
Work with tobacco (annually),	2,000
Work with poultry (annually),	2,000
Study of the agricultural resources of the State (annually),	5,000
Progressive increase in the amount available for general experimental work ($3,000 annually),	15,000[1]

The special industries, market gardening, tobacco and poultry, have for some years urgently presented their claim to addi-

[1] Annually at end of five-year period.

tional expenditure for experimental work. The values of the products annually, as nearly as can be estimated, are about as follows: —

Market-garden crops,	$8,000,000 to $10,000,000
Tobacco,	2,000,000 to 3,000,000
Poultry products,	7,000,000 to 8,000,000

The amounts of the annual appropriations asked for constitute but a very small percentage of these values. Total annual increase at the end of five years, $30,500.

4. Salary Increases.

As early as provision can be made to cover the cost, men are needed to take up additional lines of work. Among these may be named an assistant in entomology, an assistant in pomology, a plant breeder, a food investigator in microbiology, an assistant in floriculture, an assistant in agricultural economics, an assistant in poultry husbandry, an assistant in market gardening, an assistant in tobacco investigations; and besides these, as soon as we are able to take up work in these departments, assistants will be needed in forestry, rural engineering and in dairying.

There will be required also moderate increases in salaries for a considerable number of those now on the station staff. It is estimated that to provide for these new men and the needed increases will require within five years an addition to the amount now available for salaries of at least $40,000.

5. General Expenses and Equipment.

The taking up of work in new departments, and the broadening scope in departments already engaged in investigation, will require considerable new equipment. This has been quite carefully estimated by the different heads of departments. These estimates indicate that within the next five years there should be a total available for increase in equipment amounting to $15,000.

6. Summary.

Needs for land, buildings and equipment: —

Land,	$25,000
Buildings,	48,450
Increases in equipment,	15,000
Total (for five years),	$88,450

Increases in annual appropriations: —

Annual support,	$30,500
Annual salaries,	40,000
Total (at the end of five years),	$70,500

Work for Private Individuals.

A full discussion of the general policy of the station as regards work for private individuals will be found in the twenty-sixth annual report. This policy may be very briefly summarized as follows: —

The experiment station is supported by public funds. It is a public institution and expected to work in the interest of the public. It should be, therefore, and is contrary to its general policy to undertake work for individuals which has neither general agricultural nor public interest. Such work, therefore, will never be undertaken unless the right of publication and discussion of results is fully conceded.

Although the general policy is as stated, there are two lines of work for individuals which we now accept in which this general rule is not strictly applied, viz., determination of fat and solids in milk and cream, and determination of the lime requirement in soils. The results of this kind of work for individuals clearly do not have general public interest. We, for the present, however, accept this work and do it without charge, for the reason that it is believed it will favor progress in directions where it is greatly needed. Milk and cream are examined in the interest of improvement in the quality of our dairy stock and improved dairy practice; the lime requirement of soils is determined in the belief that a more general judicious use of lime will constitute a basis for much more satisfactory returns with most of our farm and garden crops. For the present, therefore, these

two kinds of work will still be undertaken for individuals to the extent to which the resources of the station permit and without charge. It should be pointed out, further, that any work believed to be of general interest which is done for individuals is done as a rule without charge.

Commercial Work.

The station recognizes no obligation to accept for pay work in the sole interest of the party applying for the same, and, unless the work desired is of a kind which it is peculiarly fitted to undertake, applications will be declined. In case the desired work is such as our staff is accustomed to handle, and for which the station is fully equipped, it may be accepted even if not of public or scientific interest, provided conditions justify the anticipation that it can be done without interference with regular work. In all such cases materials will be taken up in the order of application.

There are two kinds of work now being carried on for which a charge is made, which require brief mention: —

Water Analysis. — For a sanitary analysis of drinking water there is a uniform charge of $3. It is estimated that this charge covers the cost of the analysis. It is hardly one-third the amount which a commercial chemist usually charges. Some charge, however, seems essential in order to prevent the indiscriminate forwarding for analysis of samples in such number as to constitute a serious burden, and in many cases under conditions not indicating the need of examination.

Blood Test for Infection with Bacillary White Diarrhœa. — White diarrhœa causes such serious losses in rearing chickens that, since the discovery of the facts that it is generally transmitted through the hen that lays the egg, and that it is possible to determine whether the hen harbors the infection by a comparatively simple test of her blood, it has been felt to be desirable to undertake a campaign to eliminate the disease from the flocks of the State. For this work the station at present makes a charge of 5 cents per fowl tested. This charge is not sufficient to cover all the costs connected with the test. It is, however, felt to be perfectly legitimate that the station should carry a part of the cost, as numerous phases of investigation which it is

carrying on are closely connected with the work. On the other hand, the benefit to the individual is so great that it seems evident, since in the nature of things the test cannot within any one season be applied in all the flocks of the State, that the individual should bear a part of the cost. Applications for this work are attended to in the order in which they are received. It is more fully discussed and reported upon in the report of the head of the veterinary department, which will be found in later pages.

CONTROL WORK.

The control work with which the station is charged, viz., the administration of the fertilizer law, the feed law and the so-called dairy law, has been carried on as usual. The results are somewhat fully presented in the report of Dr. Lindsey, the head of the department of chemistry, which will be found in the following pages.

Work under the Fertilizer Law. — The somewhat abnormal conditions affecting the trade in commercial fertilizers, due primarily to the European war, have continued throughout the year. Potash salts and European basic slag meal are, practically speaking, out of the market, and prices for all materials have been and continue to be excessively high. Many brands of fertilizers ordinarily containing considerable water-soluble potash are now offered without any of this element, and this must apparently continue to be the case as long as the European war continues. There has been a slight increase in the number of brands found in our markets during the past year. The number, however, is not equal to the number before the war. On the other hand, the number of samples collected and analyzed is greater than ever before. There has, however, been a material falling off in the amount received for analysis fees on account of the fact that so large a number of fertilizers do not contain potash. Brands which formerly paid $24 ($8 for each plant-food element) now in many cases pay only $16. This situation causes considerable embarrassment, as it is feared that if the conditions existing at present continue, the amount received for analysis fees will not be sufficient to cover the cost of a satisfactory inspection. While conditions in general cannot

be regarded as satisfactory, it is a pleasure to call attention to the fact that the fertilizers sampled during the past year showed fewer commercial deficiencies than in any recent year.

FERTILIZER LAW ACCOUNT, DEC. 1, 1915, TO NOV. 30, 1916.

Balance Dec. 1, 1915,		$2,894 69	
Analysis fees,		9,400 00	
Total,			$12,294 69
Expenditures.			
Chemicals,		$407 09	
Apparatus,		312 79	
Salaries: —			
Administrative and chemical,	$6,109 42		
Clerical,	555 00		
		6,664 42	
Collection expenses: —			
Inspectors' salaries,	$827 00		
Inspectors' traveling expenses,	618 73		
Express on samples,	43 79		
		1,489 52	
Laboratory assistance,		319 32	
Official travel,		119 39	
Gas,		174 03	
Office supplies,		128 41	
Miscellaneous supplies,		97 37	
Repairs,		28 62	
Publications, Bulletin No. 4,		629 00	
Laundry,		13 68	
Fertilizer experiments: —			
Salaries and labor,	$995 00		
Equipment,	22 95		
Rent,	25 00		
Travel,	8 76		
		1,051 71	
Total,			11,435 35
Balance Dec. 1, 1916,			$859 34

Work under the Feed Law. — The number of brands of feedstuffs registered during the past year has been greater than ever before, the total for the year being 1,336. This is to be re-

gretted, since an undue multiplicity of brands necessarily means higher prices than would be necessary with a smaller number. Competition in brands would appear to have fairly run wild. The farmer would be able to obtain satisfactory feeds to meet every possible need, and at lower prices, if the number of brands was less. The results of the inspection have shown conditions in general fairly satisfactory, except as regards cottonseed meal, which in a considerable number of cases has been found below guarantee. Some prosecutions appear to be necessary.

FEED LAW ACCOUNT, DEC. 1, 1915, TO NOV. 30, 1916.

Balance Dec. 1, 1915,		$1,680 60	
Appropriation,		6,000 00	
Total,			$7,680 60

Expenditures.

Salaries: —			
Chemical,	$3,660 71		
Clerical,	250 00		
		$3,910 71	
Collection expenses: —			
Inspector's salary,	$350 00		
Inspector's travel,	381 33		
		731 33	
Laboratory assistance,		217 35	
Gas,		42 50	
Apparatus,		55 18	
Chemicals,		125 05	
Office supplies,		22 60	
Miscellaneous travel,		53 71	
Repairs,		18 16	
Sundry supplies,		83 82	
Library,		8 10	
Laundry,		8 42	
Horses for feeding experiment,		350 00	
Publication: —			
Addressing envelopes for Bulletin No. 5,		5 60	
Total,			5,632 53
Balance Dec. 1, 1916,			$2,048 07

Work under the Dairy Law. — The inspection of Babcock apparatus and glassware has shown conditions in general to be quite satisfactory, and the utility of the law requiring the examination of glassware is made very apparent by the great reduction in the percentage of pieces condemned. A few years ago the figure was often from 5 to 10 per cent., occasionally much higher; for the last two years it has been a little under .1 per cent. In 1916 out of 5,184 pieces examined only 5 were found inaccurate.

The following table with data relative to fertilizer and feed inspection will be of interest: —

Number of Official Samples.

Year.	Fertilizers.		Feeds.	
	Brands.	Samples.	Brands.	Samples.
1909,	458	1,052	196	895
1910,	487	890	195	946
1911,	519	1,063	204	1,055
1912,	527	1,180	194	902
1913,	571	1,299	227	1,115
1914,	606	1,307	1,002	924
1915,	513	1,322	1,100	1,043
1916,	548	1,398	1,336	1,109

INVESTIGATIONS IN PROGRESS.

The discussion of this subject prepared for inclusion in the president's annual report is fairly comprehensive and at the same time brief. It will be here repeated.

There has been no change in general policy and but little in lines of work in the experiment station during the year. Most of the problems under investigation are fundamental, and will require considerable periods of time for thorough study. This, it will be understood, does not mean that results of immediate value in their application to our agriculture are not being secured. Thus, for example, we are studying numerous manurial and fertilizer problems, and in every line new lanes of darkness are constantly disclosed; our results, nevertheless, enable us meanwhile to give valuable suggestions. Precisely the same situation exists in

connection with our study of feeding problems. Indeed, in almost every investigation progress establishes new facts which have a direct bearing upon practice, but at the same time discloses new vistas of needed inquiry. Frequent change in general lines of investigation not only is unnecessary, it would be highly undesirable. The general experimental work now embraces investigations in the following principal lines of inquiry: soil tests with fertilizers with different crops in rotation; comparison of the different materials available as sources, respectively, of nitrogen, phosphoric acid, potash and lime for both field and garden crops, with a view to determining the ultimate effects of each on the composition of the soil, the micro-organisms it contains and its physical characteristics; comparisons of different systems of fertilizing mowings and orchards; trial of different manures and fertilizers for both tree and bush fruits; comparison of methods of applying manures and fertilizers; variety tests of garden and field crops and fruits; tests of different spray materials and methods of spraying; comparisons of methods of pruning and of cover crops in orchard management; tests of nursery stock from different sources and of different ages; trials of new crops; determinations of the digestibility of feedstuffs; methods of feeding for milk; systems of feeding and management of poultry for eggs; efforts to determine the value and best methods of use of anti-hog-cholera serum; studies upon the diagnosis and transmission of avian tuberculosis; co-operation with selected farmers in the trial of crops and systems of fertilizing them.

In addition, the station is working upon certain research problems involving more fundamental and more strictly scientific investigation, and requiring the approval of the director of the Federal Office of Experiment Stations. The following are among the more prominent investigations of this class: —

1. To determine the principles which should underlie practice in the use of fertilizers for the cranberry crop.

2. Work in plant breeding in the endeavor to produce more rust-resistant types of asparagus (in co-operation with the Bureau of Plant Industry, United States Department of Agriculture).

3. The effect of food on the composition of milk and butter fat and on the consistency of body of butter.

4. Why insecticides burn foliage.

5. Effects of meteorological conditions on the development of plants and crops, both in health and disease.

6. Relation of light to burning from spraying with fungicides and insecticides.

7. Relation of light to burning of vegetation from miscible oils.

8. Study of interrelation of stock and scion in apples.

9. The economic importance of digger wasps in relation to agriculture.

10. The diagnosis of white diarrhœa in adult fowls.

11. A study of the presence and disappearance of organic matter in soils; its influence upon fertility.

12. A study of so-called "tobacco sickness."

The last two have been taken up during the past year; the others named have already engaged our attention for some time.

Since this statement was prepared special stabling accommodations and equipment have been provided, and horse feeding experiments which it is planned to make both thorough and scientific have been begun.

Preparations for putting out a plantation of swamp blueberries, *Vaccinium corymbosum,* for experiments in co-operation with the Bureau of Plant Industry of the United States Department of Agriculture have been made during the year.

THE ASPARAGUS SUBSTATION, CONCORD.

The sudden death of Mr. Charles W. Prescott which occurred in December was not only a great shock to his many friends but a serious loss to the work with asparagus at the substation in Concord. Mr. Prescott had been in local charge of the work from its inception until the date of his death. It was a work in which he was intensely interested, a work for which he was qualified to an unusual degree. He was a skillful farmer; he understood the requirements and the care of the asparagus crop as these are understood by few. Not only were all suggestions faithfully and enthusiastically carried out, but Mr. Prescott was himself the author of numerous valuable suggestions, and the work from start to finish owed much to his knowledge, experience and unfailing devotion.

It will be remembered by readers especially interested in asparagus that two distinct lines of work have been carried on in Concord, — first, an investigation into the plant-food requirements of the crop; and second, breeding in the effort to produce rust-resistant strains with desirable commercial characteristics. It will be remembered, further, that the plant-food investigations were discontinued at the end of last season. A brief report on the general results and advice based thereon were included in my last annual report.

The breeding work, in co-operation with the Bureau of Plant Industry of the United States Department of Agriculture, has been continued, and as heretofore has been in local charge of

Prof. J. B. Norton, whose enthusiasm, energy and industry have proved invaluable. Both observation on the different strains included in the grounds in Concord and such trials of some of the best of them as have been made by private individuals lead to the belief that the objects in view have been measurably obtained. Included among the different strains produced are several which appear to possess at the same time very superior vigor, capacity for production and quality, and much greater ability at least to resist rust than any of the kinds with which the work began. From the standpoint of the determination of the value of the new strains in respect to rust resistance the past two seasons have not been particularly favorable, since they have not been characterized by severe rust infection even of the ordinary commercial varieties.

Numerous causes have prevented rapid multiplication of the new strains, and the quantity, whether of seeds or roots, available for distribution to individuals for observation under different conditions has been comparatively small. In 1915, 99 different individuals received either roots or seed or both, the total distribution including 68 lots of roots of 50 each and 217 ounce packets of seed. In 1916 the distribution reached 74 different individuals and included 67 lots of roots of 100 each and 43 ounce packets of seed. The reports received in general speak very favorably of the new stock, which, as a rule, has been found to grow more rapidly than ordinary commercial varieties. No rust has been reported by any one receiving the new stock, but owing to the relative freedom from serious rust infestation during the past three years this fact cannot be regarded as conclusively demonstrating complete immunity.

One phase of the investigations of Prof. F. W. Morse on the chemical composition of the asparagus plant, and the effects of different fertilizers upon the proportions of the more important constituents, has been completed. The results in detail and practical conclusions based on them are embodied in a bulletin, No. 171, which is found in later pages, and which can be furnished on application as a separate.

Among the numerous facts established, the following seem to be among the more significant. The spring crop appears to be dependent chiefly upon reserve material stored in the roots the

previous season. This material is composed principally of sugars synthesized in the tops, and both synthesis and translocation to the roots appear to continue until the tops are killed by frost. The destruction of the tops by rust, or their premature removal, must lessen the amount of sugars stored in the roots, and therefore the crop of the following season.

The absence of either nitrogen, phosphoric acid or potash from the annual top-dressing limits the growth of the roots. A complete fertilizer rich in nitrogen is required in generous amounts. The percentage of nitrogen in all parts of the plant is proportional to the amounts applied. The fertilizing constituents stored in the roots over winter appear to be nearly or quite sufficient for the full development of the succeeding spring crop, although nitrogen appears to be taken in small, and lime and sulfuric acid in larger, quantities during the cropping season. Sulfuric acid appears to equal or exceed phosphoric acid in importance in the asparagus plant, but the sulfate of lime contained in acid phosphate appears to meet fully the needs of the crop for the former acid.

THE CRANBERRY SUBSTATION, WAREHAM.

Work in the cranberry substation during the past year has related as usual to a wide variety of subjects. Some of the more important results and conclusions based upon the work of the previous year have been presented in Bulletin No. 168, which will be found in later pages of this report and which can be obtained also as a separate if desired.

Experiments designed to determine the conditions under which the fruit in storage, both before and after screening, will keep best received a large share of attention. Experiments in holding the unscreened fruit under varying conditions affecting ventilation, temperature and the admixture of leaves and vines with the fruit were carried out with results which in general might have been anticipated from the known facts concerning other fruits. Among the most significant of the results of the year described in the bulletin is the demonstration of the impairment in keeping quality resulting from the ordinary methods of screening and handling. Although the berries do not show

distinct marks of bruising as a result of ordinary methods, it has been most decisively demonstrated that the system of separation by bouncing, in common use, and the fall of the berries into the barrels under customary methods of handling greatly increase the amount of decay.

Among other significant results may be mentioned demonstration of the fact that berries from fertilized plots are inferior in keeping quality to those from unfertilized areas, and especially that the use of nitrate of soda appears to increase the percentage of decay. The observations of the season indicate that spraying with Bordeaux mixture is attended with a reduction in the amount of fruit produced, and that decreased fruitfulness persists the second year. The fruit from sprayed plots, however, is considerably superior in keeping quality to that from plots unsprayed. The keeping quality is similarly improved as a result of the use of copper sulfate in the flowage, but this appears to be the only beneficial effect of the treatment.

As usual, a large share of attention has been devoted to investigations of the various insects found in the cranberry bog. The observations and experiments continue to demonstrate the efficacy of resanding and reflowing or late holding of water as methods of controlling the more injurious insects.

The bulletin contains a careful discussion of a plan to be followed in the production of cranberries which Dr. Franklin believes will considerably reduce the cost. Most briefly stated, this plan involves the adoption of such methods as will entirely prevent the production of fruit every alternate year, the more important objects in view being the elimination of grasses, weeds and insect pests at a minimum cost, bringing the vines to the bearing year in the best possible condition, and reduction in the cost of harvesting. Dr. Franklin believes that over a series of years the plan of treatment advocated will not mean lower total product of bogs so handled, as his experience and observations convince him that with proper preparatory treatment one year the vines the next will produce at least as much fruit as they will average in two years under the usual management.

The tables which follow show the nature and amount of the expenditures in the cranberry substation during the past year,

exclusive of the salary of Dr. Franklin which is not included. The so-called "bog account" includes expenditures of such character as would be essential in the ordinary commercial management of a cranberry bog; the other table includes such expenditures as are directly connected with the experimental work in progress.

Bog Account.

Maintenance: —		
Tools or similar equipment bought or repaired,	$30 03	
Oil for engine, etc.,	91 75	
Pumping plant maintenance and repairs,	42 96	
Pumping labor,	29 72	
Mowing of upland,	47 29	
Weeding,	20 69	
Lumber and hardware,	30 74	
Raking vines after picking,	35 04	
Resanding the bog,	91 00	
Cleaning out ditches,	88 80	
Miscellaneous labor,	37 71	
Express,	5 94	
Sundries,	4 02	
		$555 69
Harvesting: —		
Picking cranberries,	$606 74	
Separating,	42 23	
Screening,	168 99	
Packing,	36 73	
Carting,	44 21	
Coopering and mending boxes,	11 25	
Packing materials,	208 00	
Contingent,	2 45	
		1,120 60
Improvements: —		
Building roads,		14 00
Total,		$1,690 29

Experimental Account.

Labor,	$699 00
Supplies and apparatus,	159 08
Chemicals (including fertilizers and insecticides),	40 30
Lumber,	10 65

Traveling expenses,		$41 34
Stenographer,		59 25
Rental of dry bog for season of 1915,		50 00
Blueberry plantation: —		
Carting and spreading turf and leaf mold,	$168 60	
Survey and map of plantation,	8 50	
Plowing, harrowing and setting out of plants,	55 00	
Watering plants newly set out,	2 00	
Selecting and marking wild plants for transplanting,	21 00	
		255 10
Contingent: —		
Freight and express,	$19 08	
Telephone,	39 75	
Fuel,	28 09	
Furnishings,	5 15	
Repairs and repair materials,	4 26	
Bee rental,	6 00	
		102 33
Total,		$1,416 95

The total receipts for the fiscal year 1915-16 were as follows: —

Fruit: —		
Crop of 1915,	$906 17	
Crop of 1916,	1,737 28	
		$2,643 45
Miscellaneous,		1 00
Observations for United States Weather Bureau,		126 67
Total,		$2,771 12

Of the crop of 1916 we still have on hand a considerable proportion retained for use in storage experiments, — 80 barrels estimated to bring in $620, while the balance still due on sales of the 1916 crop is $1,185.04. The total proceeds from the sale of the 1916 crop, therefore, must amount to substantially $3,542.32.

The following comparative statements of receipts and expenditures will be of interest: —

Year.	Annual Receipts, Berries and Vines.	Annual Commercial Expenditure.	Annual Experimental Expenditure.
1911,	$5,484 43	$1,998 81	$1,639 94
1912,	1,079 87	1,985 71	1,243 25
1913,	6,675 60	2,238 02	897 51
1914,	1,973 29	1,902 07	984 69
1915,	2,445 67	2,079 94	937 39
1916,	3,542 32	1,690 29	1,416·95
Total,	$21,201 18	$11,894 85	$7,119 73
Average, six years,	$3,533 53	$1,815 81	$1,186 62+

WORK OF THE YEAR IN THE DEPARTMENTS.

In subsequent pages will be found brief reports, in most cases by department heads, covering the leading activities of the past year and calling attention to some of the more significant results obtained. Among these a few only which seem to the director to be of particular interest will be mentioned here.

Department of Agricultural Economics.

The report of Dr. Cance, the head of this department, calls especial attention to the fact that investigation of the business side of agriculture, although the possible usefulness of such investigation cannot be disputed, has received relatively little attention. The department in this institution is not yet as liberally supported financially as would be desirable, but to the extent of its resources it is investigating phases of the business side of our agriculture in which improvement seems to be most needed. The subjects so far chiefly studied are such as pertain to costs and methods of distributing farm products. Onions, tobacco and milk were among the first to receive attention. A bulletin has been issued during the year (No. 169) on "The Connecticut Valley Onion Supply and Distribution." This will be found in later pages, but can be supplied as a separate on application.

Among many other points established the following seem especially worthy of mention. Good onion land in the Connecticut valley sells at $200 to $500 per acre, and rents for from

$35 to $50 per acre annually. On such land, interest and taxes being included, the cost of raising and lifting onions in 1915 was approximately 35 cents per bushel, while the cost of topping, screening, bagging and hauling to the point of shipment was 6.8 cents per bushel. The average yield in the valley usually ranges from about 400 to 500 bushels per acre. The average price for the three years 1913–15 to farmers was about $1.14 per 100 pounds. The storage capacity in the valley is about 600,000 bushels. The average wholesale price out of storage has been about $2.20 per 100 pounds. Storage costs the owner about 11 cents per 100 pounds. The average shrinkage in storage is about 10 per cent. The usual charge for storing onions is from 23 to 25 cents per 100 pounds. This statement makes it apparent that storage generally pays, and it would seem that a larger proportion of farmers should build storage houses.

Department of Agriculture.

The principal work of this department is the carrying on of experiments bearing upon problems connected with the productive capacity of soils, largely connected with variant use of fertilizing materials supplying the different plant-food elements. In addition, however, to work of this character, crops are tested as to their adaptation to Massachusetts conditions, and varieties of the more important farm crops are subjected to comparative trials. Other lines of work consist in an effort to determine the best methods of handling and applying manures and fertilizers, and tests of different methods of tillage.

Three distinct methods are used in connection with our investigations to determine fertilizer values, namely, plot experiments in the open field; closed plot experiments in plunged cylinders with carefully mixed soils to secure uniformity of conditions throughout each series; and vegetation experiments, where each treatment is carried on in duplicate in pots under carefully controlled conditions. The work of the past year has involved the use of 257 field plots in mowing, cultivated crops, orchards and pastures; 143 closed plots; and 388 pots, the latter in vegetation experiments.

No attempt is made in the department report for this year to give a complete account of any single experiment, for each is

continued with few exceptions throughout a long series of years. Reference will be here made to a few results only, which seem to be so fully established as the result of long-continued work that there can be little question as to the reliability of the conclusions which will be stated.

Fertilizers in Addition to Manure for Market-garden Crops. — Long-continued experiments in the use of different combinations of high-grade chemicals in connection with manure at the rate of 30 tons per acre applied annually indicate that the employment of fertilizers with such an amount of manure on the soil on which the experiments have been tried — a silt loam with excellent physicial characteristics — has not resulted in increasing the crops to such an extent as to cover the cost of the materials used; indeed, with the majority of crops and in the majority of seasons there has been no appreciable increase. Notwithstanding the facts just stated, the experiments which have been so planned as to make comparisons between three of the most prominent materials which can be purchased as a source of fertilizer nitrogen — nitrate of soda, dried blood and sulfate of ammonia — have indicated the first to be the best source of nitrogen, and that sulfate of ammonia unless used in connection with liberal applications of lime may prove absolutely injurious.

Comparison of Different Phosphates. — This is a long-time experiment for the purpose of determining the relative value of the different materials found in our markets which may be used as a source of phosphoric acid. This investigation has been in progress for twenty years. Results were fully reported and conclusions on all important phases of the inquiry presented in Bulletin No. 162, which can still be obtained on application. This bulletin was prepared at the end of the eighteenth year; 1916 was the twentieth year. The results of the past year with corn tended still further to strengthen the conclusion that dissolved or acid phosphates are much preferable under the conditions of our agriculture to the fine-ground natural rock phosphates.

Methods of applying Manure. — Two methods of applying manure, namely, spreading direct on the field when hauled from the pits at various times during the winter, and placing in a

big heap in the field when hauled from the pits, to be distributed and worked into the soil in the spring, have been under comparison. This investigation continued without modification in general plan, the manure being applied in equal amounts annually for the twelve years, 1899–1911. The manure was used in both methods at the rate of 20 tons per acre, weighed when taken out of the pits. The crop yields were not uniformly favorable to either plan, but on the average of the twelve years, there being five similar experiments each year, there was no great difference in the yields obtained.

Since 1911 the plots used in this investigation have been annually planted without the addition of either manure or fertilizers. The results have shown considerable superiority in yield on the plots to which, during the first stage of the experiment, the manure was first put in a big heap and spread in the spring. Not only has the yield been greater, but the crops have made a quicker start, have kept ahead of those on the plots on which the manure was spread during the winter throughout the season, and have ripened a considerable number of days earlier. The results during the past five years, therefore (1912–16), indicate a decidedly greater residual effect from the manure applied during the earlier years of the experiment on the plots where the manure was held in a big heap until spring and then spread; in other words, the results indicate there must have been a considerable wastage from the manure spread on the other plots during the winter. That, nevertheless, the crops on the plots to which manure was applied during the winter were equal to those produced by spring application is doubtless accounted for by the fact that the manure was applied during the progress of the experiment in quantities so much in excess of the immediate requirements of the crop that the yield in spite of some wastage was maintained at the same rate as on the plots from which there was less wastage.

Department of Botany.

The general lines of work in this department, as in most others, with such modifications as are suggested by developments in the State and are the natural outgrowth of the results of work and progress, have been the same during the past year

as in recent years. While few diseases which are new to the State have come to our attention, a number which are quite unusual appeared during the past year, and several which are generally of minor importance became much more serious than usual.

In the first class belongs anthracnose of the English elm (*Glœosporium inconspicuum* Cavr.). An unusual number of other shade-tree diseases caused by other species of *Glœosporium* were prevalent, affecting, among possibly others, the Norway maple, white oak, red oak, sycamore or plane tree, beech, American elm, English elm and Lombardy poplar.

"Spindling sprout" of potatoes so seriously affected one of our experimental fields as to make it apparent that the results would have no direct evident relation to the points under investigation, and the field was plowed up. The causes of this disease are more or less obscure, but are probably connected with weakened vitality of the seed tubers.

The observations of the year make it apparent that white pine blister rust exists in every county of the State except Nantucket, and that it is most abundant in the extreme eastern and extreme western mainland counties. The different species of *Ribes* are very generally infected, and the observations made seem to afford some ground for believing that the fungus causing the disease, at least under some conditions, is able to survive the winter in *Ribes*.

In a number of localities white pines have suffered from an unusual injury noticed in various parts of this State and in a number of near-by States. The first evidence of the trouble in question is the dying of the young needles, which usually begins at the tips, though not invariably. The needles in most cases ultimately dropped, leaving the new shoots bare below the terminal tuft of needles which developed subsequent to the period of injury. It is believed that this trouble was due to the meteorological conditions which prevailed in June when the young needles were partly grown, that month being characterized by extreme humidity.

Hothouse cucumbers suffered to an unusual extent from downy mildew, a condition believed to have been favored by the wet weather of the latter part of September, in which it

occurred chiefly in houses where proper attention was not given to ventilation.

Further work with the powdery scab of potatoes indicates that this in our climate will not become a serious disease.

Dr. Chapman's investigations as to the mosaic disease of tobacco have been carried as far as at present seems desirable. His conclusion is that the trouble is caused by disturbance in the enzyme content of affected plants, and that serious losses can be prevented by sterilization of the seed bed and the avoidance of touching healthy plants immediately after touching or handling those affected with the disease.

The following articles by members of the department staff have been published during the year: —

A. V. Osmun: Maple Anthracnose. Tree Talk, Vol. 4, No. 1, p. 21, August, 1916.

George H. Chapman: Effect of Colored Light on the Mosiac Disease of Tobacco. Science, n. s., XLIII., pp. 537, 538, April 14, 1916.

Orton L. Clark: A Method for Maintaining a Constant Volume of Nutrient Solutions. Science, n. s., XLIV., pp. 868, 869, Dec. 15, 1916.

Department of Chemistry.

The report for the department of chemistry covers the various phases of its work, — research, control and miscellaneous. The control work has already been sufficiently discussed (pages 18*a*–21*a*). The miscellaneous work has been of the usual character and volume, and does not require particular mention in this place.

As usual, a large amount of attention has been devoted to a study of the chemistry and determination of nutritive value of different foodstuffs. Vegetable ivory meal, composed of shavings from the corozo nut, received a large amount of attention, and a paper reporting results has been published in the Journal of Agricultural Research ("Chemical Composition, Digestibility and Feeding Value of Vegetable Ivory Meal," Vol. VII., No. 7, pp. 301–320). The investigation made it apparent that this material, notwithstanding its hard and refractory character, is fairly digestible. It appears to be about equally digestible with corn meal.

Dr. Holland and an assistant have devoted a large share of attention to investigations in the chemistry of butter fat, and a paper on the determination of stearic acid has been published in the Journal of Agricultural Research ("Determination of Stearic Acid in Butter Fat," Vol. VI., No. 3, pp. 101–113). The work on which this paper is based makes it apparent that the methods discovered make it possible to make the determination in question with much greater accuracy than has formerly been possible. The same investigators have made much progress in perfecting methods for the determination of other acids in butter fat.

Professor Morse has brought to completion one phase of his investigations into the chemistry of the asparagus plant, and the results with practical advice based upon them are published in Bulletin No. 171, which will be found in later pages and which can be furnished on application. Attention has been called to some of the results which appear to be among the more important, and the practical conclusions based upon them, in my report for the year on the asparagus substation in Concord (pages 23*a*–25*a*).

Professor Morse and an assistant have also determined the residual effects of a long-time application of sulfate *v.* muriate of potash on Field B. The results obtained indicate no material difference in the effects of the two salts on the residual calcium, magnesium or potassium in the soil. The question as to whether there are other residual effects of importance is receiving further study.

The number of tests of pure-bred cows for admission to advanced registry has shown a marked increase, and the results of this work appear to be satisfactory to all concerned. There has been some agitation during the year in favor of permitting cow test associations, which are under the supervision of county farm bureaus, to conduct advanced registry work. Since the value of such work is clearly dependent upon its being done with absolute accuracy, it seems to those in the station connected with it advisable to keep it under our immediate close supervision. The granting of the permission referred to, therefore, has been opposed by the station, and our position has been endorsed by the Association of Dairy Instructors.

Some idea of the extent of the work in the chemical laboratories of the station may be gained by reference to the numerical summary of the laboratory work of the year on page 77*a*.

Department of Entomology.

The report of Dr. Fernald makes it apparent that fuller provision for handling that portion of the entomological work which the public reasonably expects from the college, and which considerably limits the opportunities for investigation, should be made. This part of the work of the year has involved the identification of 149 different kinds of insects and the writing of over 2,500 letters. This kind of work is much appreciated and extremely useful, but under our present institutional organization it properly belongs to the extension service.

The troublesome insects most frequently brought to the attention of the department during the year have been various kinds of plant lice, bean weevils, ants and white pine weevils, the latter probably because of the general interest in the pine connected with the knowledge of the threatened injury to this important species by the blister rust.

About 50 different species of insects have been found during the year on imported nursery stock, several of which must be regarded as potentially serious pests. This fact emphasizes the importance of careful examination of such stock and effective measures for ridding it of accompanying insect pests.

Department of Horticulture.

The more scientific and thoroughgoing investigations in this department are being carried on by Dr. Shaw. Most of these have been sufficiently referred to in recent reports. Only two new developments need be mentioned: —

The studies of local climate as affecting fruits — previous to this year carried on with especial reference to the apple in western Franklin County — have been transferred to eastern Hampden County, where observations will be made almost exclusively on the peach in the Wilbraham and Hampden district.

The only important new development has been the establish-

ment of a pruning orchard containing some 700 trees in which investigations will be conducted with especial reference to head formation.

The department of pomology of the division, under the leadership of Professor Sears, is carrying on a number of experiments in practical orcharding. Among these, the following may be referred to: —

Observations on the results of the use of miscible oil as a dormant spray, with a view to determining whether, and if so, under what conditions, it proves injurious.

Late spraying with lime sulfur to determine the limits of safety as regards leaf injury and its relation to later injury from the aphis. It appears to be entirely safe to defer the application of lime sulfur until the buds begin to start, and doing so considerably reduces the injury from aphis. The latest stage in spring development at which lime sulfur has been applied was the date when the blossom buds had begun to show pink.

A very large number of varieties of all our fruits are under careful observation and comparison. Dwarf apple trees have been extensively tested, and results convince Professor Sears that the larger dwarfs on doucin stock have a distinct value in commercial orcharding as fillers, and that they are especially suited to home plantations. The investigations in progress indicate considerable variation in the adaptation of different varieties to dwarfing; the Jonathan and McIntosh have done particularly well. Six trees of the latter variety, at the age of eight years, produced 30 boxes of fine fruit.

Experiments in very close planting of some of the smaller growing and relatively short-lived varieties, such as Wealthy, Wagener and Oldenburg, are in progress.

One of the most interesting practical experiments has been connected with the renovation of an old orchard begun in 1910. This has been very successful; and the orchard now, except for the large trunks and the scars where branches have been removed, has the general appearance of an orchard in full vigor, and is giving large yields of fine fruit.

Dextrogerm, a product which the originator believed destined to produce remarkably beneficial results, has been tried under

the immediate direction of the originator without any apparent effect, either beneficial or otherwise.

The following articles by a member of the department staff, based on station work, have been published during the year: —

J. K. Shaw: The Root System of Nursery Apple Trees. Society for Horticultural Science, Proceedings, 12, 68 (1913).

J. K. Shaw: The Origin of the Hubbardston Apple. Society for Horticultural Science, Proceedings, 12, 141 (1915).

J. K. Shaw: Fruit Trees True to Name. Rural New Yorker, LXXVI. (1915), p. 1479.

J. K. Shaw: Identification of Varieties among Nursery Apple Trees. American Nurseryman, Vol. 7, No. 1, p. 24, August, 1916.

Department of Microbiology.

The investigational work in this department during the year has been carried on under peculiar disadvantages on account of the lack of laboratory facilities due chiefly to the great delay in the completion of the new building, though aggravated by the fire which interrupted work in the temporary quarters which had been in use. As a consequence of the conditions referred to, investigational work is only just beginning in earnest.

Dr. Van Suchtelen will undertake fundamental investigation relative to the humus content of soils.

Good progress has been made in industrial research investigations supported by the De Laval Separator Company. Results obtained to date are deemed by the company to be of sufficient value to warrant still larger expenditure and the employment of additional assistants.

The department has done important work for the local board of health and the physicians of the town, and has made bacterial counts on a large number of samples of milk which have been offered in contest at a number of important dairy exhibits.

Department of Poultry Husbandry.

The more important lines of investigation in this department relate to some of the many problems connected with breeding, and in all probability must be long continued before the ends in view can be reached. The report for the poultry husbandry

department, however, announces that definite progress appears to have been made in each of the following directions: —

1. The production of a family of Rhode Island Reds characterized by high winter egg production.

2. The production of a family of the same breed characterized by high annual egg production.

3. The production of a strain of the same breed characterized by relatively little tendency to broodiness.

The work of the year has shown that Rhode Island Reds which mature early are smaller than those reaching maturity later; that the former produce the first egg earlier and will lay more eggs than the latter.

The report calls attention to the fact that weights taken make it apparent that early hatched chicks grow more rapidly than those hatched later.

The observations to which attention is called in the report for 1915 — that complete separation of newly hatched chicks from older fowls with range over new ground not only insures complete freedom from vermin and all diseases except bacillary white diarrhœa, but also much more rapid growth and greater vigor — were practically confirmed by the experience of the past year, during which not only were the chickens completely isolated but they were cared for by a man who did not come in contact with any other fowls.

Department of Veterinary Science.

The principal lines of investigation in this department during the year have been those connected with the following subjects: prevention of hog cholera, study of *Bacterium pullorum* (bacillary white diarrhœa) infection, and suppression and eradication of bacillary white diarrhœa in fowls.

The investigations connected with hog cholera have had mainly to do with a herd averaging about 150 in number of garbage-fed animals, the garbage used, at least on two previous occasions, having been the apparent source of infection. Anti-hog-cholera serum and virus both have been used extensively, a number of different commercial serums having been tried with satisfactory results. The investigation has not yet been brought to the stage when a final report seems desirable.

In the investigations connected with *Bacterium pullorum* infection, a large amount of most careful scientific work has been done. No less than 27 different strains of the organism isolated from birds in this State have been under observation since 1915, and during the past year 10 new strains have been added. The agglutinins elaborated by animals and birds are being thoroughly tested. A very large number have been examined, but up to date no toxin suitable for the further work in view has been found.

The campaign for the suppression and eradication of bacillary white diarrhœa in the State has been actively in progress since February, 1915, between which date and January, 1917, when this report was prepared, 14,851 birds have been tested. These were found in 57 different towns scattered throughout the State, and the infection appears to be quite general. Where the directions of the department as to disinfection and sanitary measures, following the removal of infected birds, have been carefully and thoroughly carried out, the result has been the practical elimination of the disease from tested flocks.

The following article by a member of the department staff, based on station work, has been published during the year: —

G. Edward Gage: Notes on the Histo-Pathology of the Intestines in Young Chicks infected with *Bacterium Pullorum*. The Journal of Medical Research, Vol. XXXIV., No. 2 (new series, Vol. XXIX., No. 2), pp. 149–155, May, 1916.

REPORTS AND BULLETINS.

The reports of the treasurer and of the different departments immediately follow the director's report. The bulletins to which reference has been made will be found in Part II. of the annual report.

WM. P. BROOKS,
Director.

REPORT OF THE TREASURER.

ANNUAL REPORT

Of Fred C. Kenney, Treasurer of the Massachusetts Agricultural Experiment Station of the Massachusetts Agricultural College, for the Year ending June 30, 1916.

United States Appropriations, 1915–16.

	Hatch Fund.	Adams Fund.
Dr.		
To receipts from the Treasurer of the United States as per appropriations for fiscal year ended June 30, 1916, under acts of Congress approved March 2, 1887, and March 16, 1906,	$15,000 00	$15,000 00
Cr.		
By salaries,	$14,241 01	$15,000 00
labor,	512 43	–
chemicals and laboratory supplies,	165 40	–
seeds, plants and sundry supplies,	48 94	–
scientific apparatus and specimens,	10 80	–
traveling expenses,	21 42	–
Totals,	$15,000 00	$15,000 00

State Appropriation, 1915–16.

Cash balance brought forward from last fiscal year,	$17,028 19
Cash received from State Treasurer,	34,750 00
fertilizer fees,	9,933 75
farm products,	7,748 37
miscellaneous sources,	11,309 94
	$80,770 25

Cash paid for salaries,	$23,989 43
labor,	21,149 16
publications,	1,570 31
postage and stationery,	1,790 44
freight and express,	508 94
heat, light, water and power,	416 66
chemicals and laboratory supplies,	1,947 64
seeds, plants and sundry supplies,	2,914 43
fertilizers,	710 56
feeding stuffs,	1,330 85
library,	1,159 28
tools, machinery and appliances,	590 43
furniture and fixtures,	121 26
scientific apparatus and specimens,	504 20
live stock,	910 11
traveling expenses,	3,884 74
contingent expenses,	35 20
buildings and land,	876 71
balance,	16,359 90
Total,	$80,770 25

DEPARTMENT OF AGRICULTURAL ECONOMICS.

ALEXANDER E. CANCE.

To gain a clear knowledge of the forces, conditions and hence the problems with which the producer must deal is the purpose of the scientific study of agriculture. Some of these forces are biological, some are physical, some are economic.

The physical and biological sciences "have to do with the harmonious adjustment of the relations between the useful forms of plant and animal life and their physical and biological environment." The science of economics deals with the effective adjustment of the relations existing between plants and animals and their human environment. These relations apply not only to the physical production of crops and animals, but to the price or value of these products, and to the persons engaged in producing, transporting or marketing them.

The chief end of agriculture and of the scientific study of agriculture is the greatest degree of prosperity (net profits) for the individual farmer and the industry, and the highest well-being of the nation. While this gives prominence to the economic motive, and makes it the background and justification for scientific study, nevertheless the three lines of investigation are mutually interdependent and equally essential. It is true that crops cannot be grown unless both the physical and biological environments are favorable; it is equally true that the supply of labor, conditions of land tenure, credit facilities, markets or agrarian legislation may and do determine production in countless instances. In the progress from primitive and self-sufficing to commercial agriculture the economic factors become increasingly important.

In the past emphasis has been laid on the study of the physical or biological forces, perhaps to the neglect of the economic.

It is true that economic conditions change more readily; that their relations are very complex; that it is often difficult to isolate and measure the results of economic forces; and that in an offhand way many of them, like many of the determining physical or biological laws, are pretty generally known. Nevertheless, the greater difficulties of the problem should not longer deter us. The economic principles underlying changing conditions are immutable. The laws of economic progress are as sure and fixed as those of biology; we need only a sufficient body of quantitative data with which to work.

New England is a rich field for the collection of data relating to the economics of agriculture, and especially the economics of marketing, the development of intensive agriculture and the agrarian relations of the State. Many of the problems are vital and press for solution. In their biological and physical aspects these questions have been given careful attention; the forces which affect prices and profits need to be studied immediately. In short, the correlation and co-ordination of the three divisions of study — physical, biological and economic — are not only desirable but essential, and this means the co-öperation of the investigators.

Some Specific Problems. — With the very limited funds at its disposal the department of agricultural economics has begun to study the costs and methods of distributing farm products. Preliminary reports on onion distribution and retail milk distribution have been prepared. A study of tobacco marketing is now under way. The possibilities of the profitable production of live stock, dairy products, poultry, potatoes, fruit and other products need to be investigated. Credit and marketing facilities for New England farmers, agricultural insurance, supply of labor and the business organization of agriculture are a few immediate problems.

The Field is Broad. — I wish that all scientific investigators might realize its immediate importance in any program for the conservation of the agricultural resources or the progress of New England agriculture.

DEPARTMENT OF AGRICULTURE.

WM. P. BROOKS AND E. F. GASKILL.

The work of the agricultural department during the past year has progressed along already well-defined lines. A large share of the work consists in the care and management of a large number of field plots which have for their object the study of various phases of the question of soil fertility. Many of the field experiments have continued over a long period of years, and a large amount of data have been accumulated which have been of great assistance in determining the specific plant-food requirements for various crops.

The work of the department during the past year has involved the use of 221 field plots, 13 orchard plots, 23 pasture plots, 143 closed plots and 388 pots in our vegetation experiments. The closed plots and the vegetation pots are used largely to check results obtained in the field. The department has also been called upon to supervise the field work on the Tuxbury land, which comprises about 20 acres, and on most of which are set young fruit trees to be used in experimental work. The care of the newly leased Tillson farm of about 75 acres has also been placed temporarily under the supervision of this department.

In presenting the work of the department from year to year it has not been customary to attempt a complete report of all the activities, but to mention and discuss only a few of the more striking results of the year. This policy will be followed this year.

Field A, or the Nitrogen Experiment.

The object and plan of this experiment have been described in several of the earlier reports. The crop this year was potatoes, which, owing to poor seed, was a failure and had to

be plowed under in July. The field was then seeded with Japanese millet. The following table shows the yields obtained on the different plots: —

Plot.	Fertilizer.	Yields per Acre.	
		Seed (Bushels).	Straw (Pounds).
0	Manure,	43.4	4,980
1	Nitrate of soda, Muriate of potash, Dissolved boneblack,	34.7	4,885
2	Nitrate of soda, Sulfate of potash-magnesia, Dissolved boneblack,	32.0	4,580
3	Dried blood, Muriate of potash, Dissolved boneblack,	27.0	5,505
4	Sulfate of potash-magnesia, Dissolved boneblack,	32.9	4,700
5	Sulfate of ammonia, Sulfate of potash-magnesia, Dissolved boneblack,	29.4	4,770
6	Sulfate of ammonia, Muriate of potash, Dissolved boneblack,	24.8	5,883
7	Muriate of potash, Dissolved boneblack,	23.6	5,623
8	Sulfate of ammonia, Muriate of potash, Dissolved boneblack,	25.3	5,865
9	Muriate of potash, Dissolved boneblack,	29.2	5,378
10	Dried blood, Sulfate of potash-magnesia, Dissolved boneblack,	25.0	5,475

Field B, Comparison of Muriate and High-grade Sulfate of Potash.

On this series of plots we have had under comparison for twenty-four years, as sources of potash, muriate and high-grade sulfate. During this time we have grown practically all the crops common in this latitude and altitude. The crops grown this year and the yields obtained are shown in the following table: —

Crop.	Potash.	Plot.	Yield per Acre.
Soy beans: —			
Beans (bushels),	Muriate,	11	29.9
	Sulfate,	12	32.0
Straw (pounds),	Muriate,	11	3,616
	Sulfate,	12	3,675
Blackberries (pounds),	Muriate,	13	1,034
	Sulfate,	14	1,060
Raspberries (pounds),	Muriate,	15	3,339
	Sulfate,	16	3,864
Corn: —			
Grain (bushels),	Muriate,	17	49.1
	Sulfate,	18	52.1
Stover (pounds),	Muriate,	17	4,221
	Sulfate,	18	4,603
Alfalfa: —			
First cutting (tons),	Muriate,	19	2.078
	Sulfate,	20	2.034
Second cutting (tons),	Muriate,	19	1.486
	Sulfate,	20	1.241
Third cutting (tons),	Muriate,	19	1.132
	Sulfate,	20	1.120

Field C, Chemical Fertilizers and Manure for Market-Garden Crops.

On this field during the past twenty-six years we have grown practically all the market-garden crops common in this State. The fertilizer schedule is so arranged that we are able to study the effect of manure used alone and with different combinations of chemicals, and we are also able to compare, as sources of nitrogen, sulfate of ammonia, nitrate of soda and dried blood; and as sources of potash, muriate and high-grade sulfate.

The unsatisfactory results obtained from time to time on the sulfate of ammonia plots led to the belief that an application of lime would improve conditions. Accordingly, in 1911 all plots were divided, and half of each plot received an application of marl at the rate of 1 ton per acre. The same half of each plot also received an application of hydrated lime at the rate of 1½ tons per acre in 1916. The following table shows the results obtained this year due to liming with the two crops onions and beets: —

Increase or Decrease due to Liming (Per Cent.).

Plot.	Fertilizer.[1]	Onions.	Beets.
0	Manure alone,	−19.2	−5.3
1	Sulfate of ammonia, Muriate of potash,	+63.1	+21.2
2	Nitrate of soda, Muriate of potash,	+ 3.7	+7.7
3	Dried blood, Muriate of potash,	+ 6.5	+17.6
4	Sulfate of ammonia, Sulfate of potash,	+60.2	+13.9
5	Nitrate of soda, Sulfate of potash,	− 6.2	+2.9
6	Dried blood, Sulfate of potash,	− 1.3	− 2.3

[1] No potash applied this year.

These figures indicate very clearly the results of the application of lime. With the onion, the most striking results were obtained on plots where sulfate of ammonia had been used continuously since the beginning of the experiment, the crop on these plots being increased 63 and 60 per cent., respectively. Little benefit was noted from the application of lime on any of the other plots; in fact, it seemed to have a detrimental effect on some, the crop on the manure plot, for instance, being 19 per cent. less on the limed area than on the unlimed area.

Determinations of the lime requirement of the soil from the different plots previous to the application of lime showed the following to be true: —

Lime Requirement per Acre to Neutralize Acidity.

Plot.	Tons.	Plot.	Tons.
0,	2.40	4,	5.00
1,	4.75	5,	2.40
2,	2.40	6,	3.00
3,	2.80		

For the last six years certain areas of each plot have been continuously in onions. The following table shows the yields obtained each yeaı, the average for the five years previous to 1916, and the yield for this season. These figures represent the total yields of the different plots, both limed and unlimed areas.

Onions, Yields Bushels per Acre (Whole Plot).

Plot.	1911.	1912.	1913.	1914.	1915.	Average of Five Years, 1911-15.	1916.
0,	429.7	184.6	156.3	594.8	439.0	360.9	656.2
1,	321.3	160.8	68.5	298.6	381.0	246.0	511.8
2,	327.7	141.8	114.8	547.5	294.5	285.3	637.2
3,	367.3	110.3	76.9	491.1	225.0	254.1	614.3
4,	229.9	118.1	46.5	279.0	334.0	201.5	467.8
5,	341.8	113.8	109.6	551.9	253.0	274.0	693.7
6,	382.6	93.2	82.3	445.6	227.0	246.1	607.5

The figures show that for the onion crop, with one exception, no benefit is derived from the addition of chemicals to manure; that the best source of nitrogen is nitrate of soda, and the source least beneficial to the crop is sulfate of ammonia; and that there is very little difference between the two sources of potash.

Considering the fact that no potash was applied this year, it would seem that on land in a high state of cultivation, which has received liberal annual applications of fertilizers containing potash, a good crop might be expected for at least one year without the use of any potash.

Comparison of Different Phosphates.

This experiment was begun in 1897, and has for its object a comparison of ten different materials that may be used as sources of phosphoric acid. The data for the first eighteen years of the experiment were published in Experiment Station Bulletin No. 162. The crop this year was field corn, and the results obtained are shown in the following table: —

Plot.	Fertilizer.	Hard Corn (Bushels).	Soft Corn (Bushels).	Stover (Pounds).	Increase over no Phosphate.	
					Hard Corn (Bushels).	Stover (Pounds).
1,	No phosphate,	80.6	2.3	7,920	-	-
2,	Arkansas rock,	80.1	1.5	7,840	.9	200
3,	South Carolina rock,	80.3	2.1	8,520	2.5	1,160
4,	Florida soft rock,	83.1	1.9	8,320	6.6	1,240
5,	Slag,	75.9	1.9	8,080	.8	1,280
6,	Tennessee rock,	74.6	1.6	6,440	.9	—80
7,	No phosphate,	72.3	1.4	6,240	-	-
8,	Dissolved boneblack,	75.9	2.0	7,857	6.5	1,917
9,	Raw bone,	75.9	2.2	8,250	9.4	2,610
10,	Dissolved bone meal,	75.3	1.5	7,600	11.7	2,260
11,	Steamed bone,	74.3	1.7	7,400	13.6	2,360
12,	Acid phosphate,	70.3	1.0	6,400	12.5	1,660
13,	No phosphate,	54.9	1.1	4,440	-	-

Field G, Comparison of Potash Salts.

This is the nineteenth year of this experiment which has for its object the study of seven different materials which may be used as sources of potash. There are 40 plots in all, 5 check or no-potash plots, and 5 plots on which each of the different potash materials are used. All plots receive an annual application of nitrogen and phosphoric acid. The different materials used as sources of potash are kainit, high-grade sulfate, low-grade sulfate, muriate, nitrate, carbonate and feldspar.

The crop during the past year was mixed grass and clover. The following table shows the average yields per acre with each material furnishing potash: —

Potash.	Hay (Pounds).	Rowen (Pounds).	Total (Pounds).	Rank, no Potash equals 100 Per Cent.
No potash,	4,280	1,624	5,904	100.0
Kainit,	5,320	1,608	6,928	117.3
High-grade sulfate of potash,	4,720	1,586	6,306	106.8
Low-grade sulfate of potash,	4,800	1,570	6,370	107.9
Muriate of potash,	4,840	1,656	6,496	110.0
Nitrate of potash,	5,000	1,768	6,768	114.6
Carbonate of potash,	4,360	1,578	5,938	100.6
Feldspar,	4,320	1,864	6,184	104.7

While the yield obtained (being about 3 tons per acre of hay and rowen) must be considered quite. satisfactory, it will be noticed that there is not a great difference in yield on the different plots. This lack of variation is explained largely by the fact that there was very little clover on any of the plots this year. In former years, when the crop has been mixed grass and clover, the noticeable difference in the yields on the different plots has been due largely to the fact that the clover seemed to do better on plots where high-grade and low-grade sulfate of potash were used.

Considering the whole period covered by the experiment we find that high-grade sulfate of potash has proved the best source of potash for legumes; that no benefit has been derived from the use of feldspar, either in large or small quantities; that kainit and muriate have given fully as good results as the other potash salts when the crop was timothy and red top; and that when potatoes have been grown the no-potash plots proved less resistant to blight than the other plots.

North Corn Acre.

The object and purpose of this experiment is quoted from last year's report: —

For twenty-six years there have been under comparison on this field two fertilizer mixtures. In one, the percentage of potash is high and that of phosphoric acid low; in the other (which represents about the average analysis of the commercial corn fertilizers offered on our markets) the percentage of phosphoric acid is high and that of potash low. For twenty years the rotation on this field has been two years grass and two years corn. The seed (a mixture of timothy, red top and clover) has usually been sown in the standing corn the latter part of July. The soil has not had the benefit of a green manure crop nor an application of manure during the twenty-six years of the experiment. The turf and corn stubble which have been plowed under have been the only source of humus.

The combination of chemicals rich in phosphoric acid was applied the same as in previous years, taking the average analysis of corn fertilizers previous to the reduction in the percentage of potash. The crop this year was corn, and the yield of crib-dried corn obtained was at the rate of 45.9 bushels per acre, and

the stover on this plot was at the rate of 5,240 pounds per acre. The yield on the plot receiving the combination rich in potash was 30.4 bushels per acre of crib-dried corn, and 4,660 pounds per acre of stover.

North Soil Test.

This experiment began in 1890, and has for its object a study of the effect of the continued use of fertilizers containing single plant-food elements and different combinations of plant-food elements for different crops; also the effect of lime added to each fertilizer under comparison. The west half of each plot received an application of hydrated lime at the rate of 1 ton per acre in 1899 and again in 1904. The application in 1907 was at the rate of one-half ton per acre, and in 1916 ground limestone at the rate of 2 tons per acre was applied. The crop this year was field corn. The following table gives the fertilizer schedule and the yields per acre for this year: —

Plot.	Fertilizer.	Limed.		Unlimed.	
		Corn (Bushels).	Stover (Pounds).	Corn (Bushels).	Stover (Pounds).
1	No fertilizer,	18.7	1,200	21.3	1,600
2	Nitrate of soda,	19.7	1,600	34.5	2,200
3	Dissolved boneblack,	21.7	1,600	35.1	3,000
4	No fertilizer,	31.5	2,000	28.8	2,600
5	Muriate of potash,	36.9	2,600	25.9	3,000
6	Nitrate of soda, Dissolved boneblack,	41.3	2,800	43.3	3,600
7	Nitrate of soda, Muriate of potash,	45.7	3,800	25.1	2,900
8	No fertilizer,	31.9	2,400	16.3	1,400
9	Dissolved boneblack, Muriate of potash,	48.1	4,000	30.3	2,500
10	Nitrate of soda, Dissolved boneblack, Muriate of potash,	51.2	4,200	38.3	4,200
11	Plaster,	27.9	2,000	19.9	2,000
12	No fertilizer,	26.4	1,600	14.5	1,200
13	Nitrate of soda, Dissolved boneblack, Muriate of potash, Dried blood,	56.3	5,200	43.1	4,000

As in previous years, when corn has been grown on these plots, the largest yields are obtained on the plots where potash is used. The materials are not used in such quantities as would be expected to produce large crops. The continued use for twenty-seven years of the same materials on the same plots has furnished a mass of data as to the specific plant-food requirements of different crops.

Grass Plots.

The experiment in top-dressing permanent mowings with different materials used in rotation has been continued, but owing to the scarcity of potash this material was not applied the past season. In the following table will be found the fertilizer schedule and the yields per acre obtained on each for this year: —

Fertilizers.	Hay (Pounds).	Rowen (Pounds).	Total (Pounds).
Barnyard manure,	4,630	2,110	6,740
Bone and potash,[1]	4,267	1,942	6,209
Slag and potash[1] (earlier ashes plot),	4,450	1,581	6,031

[1] No potash was applied in 1916.

The average yields to date under the three systems of top-dressing are: —

	Pounds per Acre.
When top-dressed with manure,	6,038
When top-dressed with bone and potash,	5,911
When top-dressed with wood ashes (slag and potash now used),	5,628

The past season was very favorable to the production of a large hay crop, and in spite of the fact that the potash was omitted from the different mixtures the yields obtained on all the plots were considerably above the average yields on these plots. The results obtained this year would seem to indicate that on permanent mowings, where it has been the custom for several years to apply annually a liberal application of chemicals or manure, potash may be omitted for at least one year and still a normal crop be obtained.

Sulfate of Ammonia *v.* Nitrate of Soda as a Top-Dressing for Permanent Mowings.

This is the ninth year of the experiment in which, it will be remembered, we are using sulfate of ammonia and nitrate of soda in such quantities as to furnish equal nitrogen.[1] The following table gives the fertilizer schedule and the yields per acre for this year: —

Plot.	Fertilizer.	Rate per Acre (Pounds).	Hay (Pounds).	Rowen (Pounds).	Total (Pounds).
1	Sulfate of ammonia, ...	200	5,707	1,476	7,183
2	Nitrate of soda, ...	266⅔	6,659	1,463	8,122
3	Check plot, ...	-	4,756	1,427	6,183
4	Sulfate of ammonia, ...	150	5,293	1,354	6,647
5	Nitrate of soda, ...	200	4,854	1,561	6,415

Although the potash was omitted from all these plots this year a very satisfactory crop was obtained on all of them. The results are in accord with those of previous years with one exception, namely, the rowen crop on the check or no-nitrogen plot is much smaller in proportion this year than that obtained on the other plots.

The Lime Experiment.

This is the third year of the experiment which has for its object a study of the relative value of different sources of lime on the basis of equal application of combined calcium and magnesium oxides. The field on which this experiment is being carried out is the one on which for several years we compared the practice of spreading manure in winter with the practice of piling it on the field in the winter and spreading it in the spring. In the manure experiment there were five plots, each being divided into a north and a south half. The manure was hauled to the field in the late fall and winter, and that for a single pair of plots was hauled at one time, usually the same day; the loads were placed alternately on the north half, where

[1] All plots received an equal application of phosphoric acid. No potash was applied in 1916.

it was spread, and on the south half, where it was put into a large pile. Carefully preserved manure from well-fed dairy cows was applied to the first four pairs of plots, and stable manure from horses was applied to the fifth pair. The experiment began in 1899, the manure being applied annually through 1911. Since then no manure or fertilizer has been applied the object since 1911 being to test the residual effect of the two systems of manuring.

The results indicated that the difference between the two systems of manuring was small, but almost invariably in favor of the practice of piling in winter and spreading in the spring. This is not only true of the period (1899–1911) when manure was applied annually, but also true of the period (1911–14) when no manure or fertilizer was applied.

In planning the lime experiment which began in 1914 it was decided to use four kinds of lime, as shown in the following table: —

Plot.	Manure Experiment.	Lime Experiment.
1,	North half, winter application, South half, spring application,	Hydrated lime.
2,	North half, winter application, South half, spring application,	Marl.
3,	North half, winter application, South half, spring application,	Ground limestone.
4,	North half, winter application, South half, spring application,	No lime.
5,	North half, winter application, South half, spring application,	Limoid.

In the spring of 1914 the different forms of lime already mentioned were applied in such quantities as to supply equal amounts per acre of calcium and magnesium oxides. No fertilizer or manure has been applied since 1911, and only one application of lime has been made. In 1914 and 1915 the crop was soy beans. This year the crop was field corn. The following table gives the yields per acre of all the crops since the beginning of the experiment: —

Plot.	Lime.	Soy Beans. Cut Green (Pounds).	Soy Beans. Beans (Bushels).	Soy Beans. Straw (Pounds).	Corn. Grain (Bushels).	Corn. Stover (Pounds).
1,	Hydrated lime,	13,692	31.20	2,484	60.3	4,057
2,	Marl,	13,738	30.00	2,435	53.4	3,839
3,	Ground limestone,	9,887	30.02	2,359	50.7	3,334
4,	No lime,	9,250	28.86	2,273	48.2	2,958
5,	Limoid,	10,437	35.25	3,209	58.8	4,878

It will be seen that the two forms of lime that have given the best results for all crops are the hydrated lime and the limoid. Although this is the fifth year since these plots received an application of manure or fertilizer, the yield of grain this year ranged from 48.2 bushels per acre of crib-dried corn on the no-lime plot to 60.3 bushels on the hydrated lime plot.

The soy bean is not a crop that draws heavily upon the supply of soil nitrogen, yet both years when this crop was grown the south half of each plot (that portion of the plot which formerly received the application of manure in the spring) looked better all through the growing season and produced the larger crop at harvest. The same results were obtained this year with corn, with the exception of one plot, as is shown in the following table: —

Plot.	Lime.	North Half. Grain (Bushels).	North Half. Stover (Pounds).	South Half. Grain (Bushels).	South Half. Stover (Pounds).
1	Hydrated lime,	53.3	3,463	67.2	4,650
2	Marl,	44.1	2,849	62.7	4,828
3	Ground limestone,	36.7	2,275	64.7	4,393
4	No lime,	44.7	2,236	51.7	3,680
5	Limoid,	60.7	4,432	56.8	5,303

Considering the data obtained during the three years of this experiment it would seem from the standpoint of crop production that first place must be given to the hydrated lime. They also show that land which has received annually a liberal application of manure for several years will produce satisfactory crops for some time without further fertilization.

Variety Test Work.

The testing of different varieties of potatoes, alfalfa and soy beans has been continued during the past year.

Further experiments with alfalfa lead to the conclusion that the so-called Grimm variety is not enough better than the common variety to warrant paying the higher price for the Grimm seed. In the early experiments comparing Grimm and common alfalfa, the Grimm variety produced the larger yield, but in later trials the yield of common alfalfa has been at least equal to that of the Grimm, and indeed in many cases it has exceeded the Grimm. It has not been our experience that the Grimm variety is any more hardy than the common alfalfa produced from good northern-grown seed. In all our trials the best seed obtainable has been purchased of both varieties, and it is our conclusion that good northern-grown seed obtained from reliable sources is just as satisfactory as the higher-priced Grimm seed.

There is a good deal said and written in these days concerning the importation of different varieties of alfalfa from Siberia and other northern countries. In one of our experiments we have had under comparison with common and Grimm one of these Siberian varieties. The seed was obtained from Professor Hansen of South Dakota, and was said by him to be the best of all imported varieties. We paid $5 per pound for the seed, and took all possible precautions to insure a good stand. The variety proved absolutely worthless, being a low growing one that winterkilled more than the common or Grimm varieties, and did not yield nearly as satisfactory a crop.

Seed from several of these imported varieties are offered for sale on our market at fabulous prices. The purchase of such seed, especially in large quantities, is not recommended. A variety may do well in northern Siberia, and, when the same variety is grown in the Dakotas and Minnesota, where climatic and soil conditions are somewhat similar to those in Siberia, may do equally as well and prove a very profitable variety for that locality. It does not, however, follow that the same variety will succeed in New England under entirely different soil and

climatic conditions. The fact that we have a much greater rainfall in New England than is common in the Dakotas may explain in a large measure the failure of some of the varieties in New England that do well in the west.

From our experiments and observations we are convinced that alfalfa can be grown successfully in Massachusetts, but the following points [1] are regarded as absolutely necessary if a good stand is to be secured: —

1. Careful selection of the location and the type of soil.
2. Particular care in the preparation of the seed bed.
3. Proper application of lime and fertilizers.
4. The selection of a good, reliable strain of seed.
5. Proper care of the crop after a good stand is secured.

[1] A bulletin, No. 154, making suggestions on all these points will be sent on application.

DEPARTMENT OF BOTANY.

A. V. OSMUN.

With certain additions, the activities of the department have continued along lines previously reported. Work which may be considered as public service, including plant disease diagnosis, seed work, and correspondence pertaining to these and a great variety of other botanical matters, has increased to a considerable extent. As pointed out in the last annual report of the writer, this work seriously interferes with research, and it is hoped that the time may not be long postponed when extension service funds will be available to care for it.

As in previous years, plant disease work has occupied the greatest amount of attention. Reports of diseases new to the State have been few, but a number of unusual diseases appeared, and some others commonly present in minor degree were widespread, and particularly severe in their outbreaks. Diseases not previously noted in the State are a vine blight of *Aristolochia*, caused by an undetermined species of *Glœosporium*, and an anthracnose of English elm, caused by *Glœosporium inconspicuum* Cavr. The former disease was not uncommon during the summer, but in all cases noted, save one, little damage was done. In the one case a very large vine was completely defoliated, and practically all new shoots became blackened and died.

An unusual number of shade-tree diseases caused by species of *Glœosporium* were noted. Trees on which such diseases were observed included sugar maple, Norway maple, white oak, red oak, sycamore or plane tree, beech, American elm, English elm and Lombardy poplar. Preliminary work, including a limited number of cross inoculations, leads the writer to suspect that the same fungus may be responsible for several of these diseases, but positive proof has not been established.

"Spindling sprout" of potatoes was reported from several localities. The most severe case was noted in Field A of the experiment station plots. This field is divided into eleven plots for experiments to determine the relative value of different sources of nitrogen. No difference was observed, however, in the severity of the disease on the different plots, and it is extremely doubtful if the soil treatment bore any relation to the trouble. Spindling sprout appears to be due to weakened vitality of seed tubers. Whether the primary cause is always the same is not known. It is conceivable, however, that either unfavorable storage conditions, or the presence on the parent vines of such diseases as late blight and *Rhizoctinia* stem rot, might be responsible for the condition. It is worthy of note that the seed tubers from which the spindling sprouts developed were to all outward appearances sound and healthy, and that before planting they were treated with formaldehyde. That the method of disinfection was not at fault is indicated by the fact that a second lot of tubers from the same source as the station supply, planted in another locality without disinfection, developed the disease with equal severity.

An unusual condition, difficult of explanation, existed relative to the late blight of potatoes, caused by *Phytophthora infestans* (Mont.) deBy. A wet June and July, with only five clear days and the humidity above normal, presaged trouble, especially in view of the very serious outbreak of the disease the previous year. It was somewhat surprising, therefore, that comparatively little blighting of vines actually occurred. This may probably be explained by the high temperatures during July and August and scant rainfall in the latter month. Despite the absence of vine blighting, tuber infection with *Phytophthora* was unusually prevalent and severe, and heavy loss has resulted from decay, both prior to and since storage. So general has been tuber decay that market lots of potatoes free from the diseases have been difficult to find. The writer has been inclined to attribute this condition to mild infection during late July and August (the period when vine blighting is normally most severe), during which time conditions were such as to retard development of the causal fungus, followed by abundant rainfall, high relative humidity, and generally lower tempera-

tures in September, which favored the development of the fungus below ground.

Interest in the white pine blister rust has been very general, owing largely, undoubtedly, to the recent publicity given this disease. Special appropriations by State and Federal governments have made possible a more or less complete survey of the State, under the direction of the State Nursery Inspector, which reveals the widespread presence of the disease. It is now known to occur in every county of the State except Nantucket. Indications are that pine infection is confined largely to the extreme eastern and western parts of the State, with a few scattered centers of pine infection between. On the other hand, Ribes are generally infected throughout the State, often in centers far removed from any pines known to be affected with the disease. This condition is of interest as bearing on the question of overwintering of the blister rust fungus on Ribes. Coupled with the appearance of the disease on currants shipped while dormant to apparently rust-free localities from nurseries known to have been infected the previous year, this may be considered as an important addition to the evidence accumulating in support of the supposition that the fungus may occasionally survive winter in the tissue of Ribes. With the disease widely distributed in the United States and Canada its further spread appears inevitable, and in all probability its complete eradication from State or nation can never be accomplished. That it will ever become as destructive as the chestnut canker, however, seems to the writer extremely doubtful.

An unusual injury to white pines, apparently due to weather conditions, was prevalent throughout the State, and was also observed in several near-by States. The trouble was evidenced by the dying of the young needles. Usually dying began at the tips, but in some cases was first apparent near the middle and at the base of the needles. In most instances the injured needles finally dropped, leaving the new shoots bare below the terminal tuft of needles which developed subsequent to the period of injury. The dying of the needles seems unquestionably to have been due to meteorological conditions which prevailed in June when the young needles were partly grown. The period was one of alternating cloudy and very bright days,

with extreme humidity. Such conditions promoted rapid, but soft and tender, growth. In consequence the delicate young needles of many trees were burned or scalded by the intense rays of the sun. That injury occurred on some trees and not on others near-by, and apparently growing under identical conditions, is explained by the fact that the injured trees probably were either further advanced or somewhat backward in their development. However, as special observations were not made during the period of injury there is no definite evidence bearing upon this point. In all probability the injured trees, except those most severely affected, will recover under normal conditions next season, but the injury described has caused a distinct check in their development. This trouble should not be confused with a similar trouble described by Dr. G. E. Stone in 1910[1] and attributed to sun scald. The latter was shown to be primarily due to root injury, either through winterkilling or extreme drought, which prevented the maintenance of a proper balance between absorption and transpiration, resulting in drying out and death of the needles. This trouble occurred quite as frequently on the old needles as on the young, while the trouble which appeared last season was wholly confined to the newly formed needles.

Several severe outbreaks of downy mildew on greenhouse cucumbers were reported early in October. This belated appearance of the disease was unexpected in view of its relative unimportance during July and August, the period when normally it reaches its maximum development in Massachusetts. The late occurrence of the disease may possibly be explained by the wet weather of the latter half of September, and the failure on the part of the growers to dry out their houses by the use of heat and proper ventilation.

The experiment to test the ability of the potato powdery scab organism (*Spongospora subterranea* (Walbr.) Lag.) to produce the disease under Massachusetts conditions, noted in the last annual report of the writer, was repeated the past season with negative results. This evidence, added to similar results obtained in other eastern States south of Maine, indicates that powdery scab need no longer be considered as a possible menace

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[1] Twenty-second annual report, Mass. Agr. Expt. Sta., 1910, pp. 65–69.

to the potato growing industry of this State. Furthermore, data accumulated by investigators for the United States Department of Agriculture seem to indicate a close relationship between this disease and soil and weather conditions which does not exist in Massachusetts.

For many years tobacco growers have experienced difficulty in growing tobacco on certain soils which have been more or less continuously planted to this crop for long periods. The trouble seems obscure in its nature, but it is generally attributed to soil conditions growing out of failure to practice crop rotation. The condition is commonly referred to as "tobacco sick soil." Numerous attempts have been made to solve the problem, but comprehensive investigations have not been undertaken. Tobacco growers have been insistent in their calls for help, and the situation has recently so shaped itself that special investigation of the problem by the station seemed imperative. The matter has been referred to the department of botany, and because of his special fitness, Dr. G. H. Chapman has been assigned to the work. A small appropriation by the last Legislature made possible the purchase of some special equipment and the construction of cement beds in the department greenhouse to be used in this work. It is hoped that further provision will be made in the next legislative session for the prosecution of the work on a much larger scale.

With the growth of the onion industry in the Connecticut Valley there has been an increasing tendency to store the crop for periods of varying length, regulated largely by the market demand and price. Large losses from decay frequently occur in the storehouses, and every storer expects more or less shrinkage from this source. There seems to have been little study of the storage problem to determine the factors which contribute to success or failure. The chief difficulty in the way of success appears to be inability to control decay, although shrinkage due to loss of water by evaporation is a considerable factor. The increasing importance of the onion crop in Massachusetts has led the department to undertake investigations with a view to working out methods of controlling storage rot. It is too early, however, to make more than a report of progress.

In addition to the new work undertaken during the year in connection with the tobacco and onion crops, projects have been accepted for investigations on Antirrhinum rust and a systematic and ecological study of the grasses of the Connecticut Valley. Work on the former was started by W. L. Doran, a graduate assistant in the department, prior to his acceptance in November of a position at the New Hampshire Experiment Station, where he is continuing his investigations. It is expected that the results will be embodied in a thesis to be presented for the master's degree and published by this station. The latter work will be conducted by Donald White, also a graduate assistant in the department, and will form the basis of his thesis for the doctorate.

Progress has been made on all research projects presented previous to the current year. Of these, investigation of tobacco mosaic, which has been under way for several years, has been completed, and early publication of the results may be expected.

DEPARTMENT OF CHEMISTRY.

J. B. LINDSEY.

There are several sections in the department of chemistry and a brief report on the work of each is presented.

1. Research Section.

(*a*) Studies on the chemistry and nutritive value of vegetable ivory meal by Mr. Beals and Dr. Lindsey have been brought to a close, and the results published in the "Journal of Agricultural Research," Vol. VII., No. 7. The material consisted of the ground shavings from the ivory or corozo nut (*Phytelephas macrocarpa*). It was of a tough, horny nature, tasteless and odorless, and contained very little protein and fiber and practically no fat. The carbohydrates were practically all mannan, hydrolyzing into mannose. They were more slowly hydrolyzed than starch. Experiments with sheep showed it to be practically as digestible as corn meal. It has a distinct nutritive value as a component of a grain ration, but does not equal corn meal. It was not possible to determine its exact relative feeding value.

(*b*) Studies of the digestibility of wheat gluten, distillers' grains, corn bran, garbage tankage, feterita (one of the sorghums), sweet clover, Sudan grass, Schumacher's stock food and vinegar grains have been completed.

(*c*) Studies on the comparative values of alfalfa and ordinary hay for milk production and as a source of milk protein are still in progress. The protein in alfalfa hay and corn meal appears to be fully as valuable as a source of milk protein as does that derived from ordinary hay and corn gluten products. The effect of alfalfa hay as a depressor of the milk yield because of its diuretic effect and its increasing of the metabolism is being carefully noted.

(*d*) Digestion experiments with horses have been begun. As this is a new line of work at this station, considerable time has been required to construct satisfactory equipment for collecting the feces and urine. Observations will be carried on during the spring, summer and autumn as to the most satisfactory rations for work horses.

(*e*) Dr. Holland and Mr. Buckley have continued their studies in the chemistry of butter fat. An article on the determination of stearic acid in the insoluble acids of fats has been published in the "Journal of Agricultural Research," and a general revision of the usual group methods of fat analysis published as Bulletin No. 166 of this station.

(*f*) The analytical work relative to the stability test with olive oil has been completed, but a report has not as yet been prepared for publication.

(*g*) During the past year considerable progress has been made in perfecting a method for the determination of caproic, caprylic, capric, lauric and myristic acids in butter fat. The process consists essentially of four distinct steps: —

(1) Esterification of the fat.

(2) Purification of the esters.

(3) Fractional distillation.

(4) Analysis of the resulting fractions.

Numerous difficulties were encountered in the first three phases, but they are gradually being eliminated and more satisfactory results secured.

(*h*) The widespread use of lime-sulfur solutions by the horticulturists of the State, and the demand for an immediate report on samples sent for examination, necessitated considerable study on methods of analysis in order to enable us to advise promptly as to the quality of the submitted products.

Mr. Morse reports concerning his investigations: —

The asparagus investigations which have been conducted for several years have been compiled and put into a bulletin which is in press. During the season of asparagus cutting last spring several series of samples were prepared for the purpose of determining the rate of change in asparagus during the period which elapses between cutting and cooking. The samples were analyzed just before the close of the year. The results indicate

the importance of cooling the crop and handling it as one would handle delicate fruit. It appears possible to retain the crop for a week or more in cool storage by observing precautions, and thus aiding in a better distribution of the crop in the market.

Soil Investigations. — Mr. Ruprecht was absent during the first half of the year, studying at Cornell University. While away and since his return, until his resignation at the close of the year, he was engaged in comparing samples of soils from Pennsylvania, Ohio and Rhode Island, which had been treated for long periods of time with sulfate of ammonia. The results were corroborative of those obtained on the soils of Field A at this station.

The residual effects of the long-time application of sulfate *versus* muriate of potash on Field B have been studied, using for this purpose the soils from six of the plots in this field. Mr. Beals made numerous analyses, and the results obtained showed practically no differences in the effects of the two salts on the residual calcium, magnesium or potash.

The fact that our fertilizer plots have been maintained continuously for many years suggested the possibility of valuable results from a study of the hydrogen ion concentration in the soil solution and the effect of the common fertilizer chemicals on this concentration where used over long periods of time. A considerable amount of preliminary work has been done to develop the best mode of procedure in the investigation.

Cranberry Investigations. — The comparatively small amount of work done in this line during the past year has been a continuation of that mentioned in the last report.

2. Fertilizer Section.

The work of the fertilizer section, in charge of Mr. Haskins, with Messrs. Walker, Jones and Allen as assistants, may be summarized as follows: —

(*a*) *Fertilizers registered.*

During the season of 1916, 108 manufacturers, importers and dealers have secured certificates for the sale of 515 brands of fertilizer, fertilizing materials and agricultural limes, classed as follows: —

Complete fertilizers,	222
Ammoniated superphosphates,	133
Ground bone, tankage and dry ground fish,	56
Wood ashes,	8
Chemicals and organic nitrogen compounds,	60
Agricultural limes,	36
	515

(b) Fertilizers collected and analyzed.

During the year, 9,668 tons of fertilizer were sampled, necessitating the sampling of 22,122 sacks. In this work 155 towns were visited; 1,398 samples, representing 548 distinct brands, were drawn from stock found in the possession of 414 different agents or owners.

Eight hundred analyses (552 distinct brands) have been made during the year's inspection: —

Complete fertilizers,	275
Ammoniated superphosphates,	177
Ground bone, tankage and dry ground fish,	95
Nitrogen compounds,	132
Phosphoric acid compounds,	32
Wood ashes,	48
Lime compounds,	41
	800

Full details regarding the fertilizer inspection work will be found in Bulletin No. 6, Control Series, published in December, 1916.

(c) Other Activities of the Fertilizer Section.

During the months of December, January, February and March time is usually taken to do co-operative analytical work on some of the problems of the Agricultural Department, in connection with field and pot work. Following is a brief summary of these activities: —

Ash analysis of 8 samples of corn grain.
Ash analysis of 8 samples of corn cob.
Ash analysis of 4 samples of corn stover.
Weights and dry matter on 260 samples of millet straw and 260 samples of millet seed.

The grinding of both straw and seed in preparation for this work was done by student help. Forty of the samples of millet straw and seed were later tested in duplicate for nitrogen and potash, 19 for nitrogen and phosphoric acid, 12 for nitrogen, phosphoric acid and potash, and 42 for nitrogen alone.

Forty-eight samples of subsoil, collected in various sections of the State, have been tested for their acid soluble potash; complete mechanical analyses were also made on these samples.

Four hundred and ninety-three different substances have been received and analyzed for farmers, farmers' organizations and the various departments of the experiment station: —

Fertilizers and by-products used as fertilizers,	197
Lime products,	20
Soils for lime requirement and organic-matter tests,	220
Soils for complete analysis,	2
Soils for partial analysis,	28
Tobacco, onion and greenhouse soils, special analysis of water-soluble constituents,	23
Miscellaneous,	3
	493

The usual interest and co-operation has been taken in the activities of the Association of Official Agricultural Chemists. Mr. Haskins has served as referee on nitrogen for the year, planning the work, preparing and forwarding samples for analysis, and compiling the final report on this subject for the association.

(*d*) *Vegetation Tests.*

In 1913 an experiment was begun to study the availability of phosphoric acid in basic slag phosphate by means of vegetation tests. This work was in co-operation with the basic slag committee of the Association of Official Agricultural Chemists. The preliminary work on this field during 1913, 1914 and 1915 was confined to a systematic management and cropping, intended to deplete the phosphoric acid in the soil. The final tests were made during the past year, and included a study of the effect of different phosphoric acid compounds on 42 plots, each having an area of one-eightieth of an acre, rape being the

crop grown. The analytical work connected with this experiment will be completed during the next two months, and results will be forwarded to the chairman of the committee of the association.

During the year three series of pot experiments, two of rape and one of millet, each comprising 46 pots, have been completed in the study of this same phosphoric acid availability problem. Considerable analytical work still remains to be done before results will be available to the association or for publication.

3. Feed and Dairy Section.

A summary of the work of the feed and dairy section in charge of Mr. Smith, assisted by Messrs. Beals, Borden, Davis and J. B. Smith follows: —

(a) *The Feeding Stuffs Law (Acts and Resolves for 1912, Chapter 527).*

During the past year 1,109 samples of feeding stuffs were collected at 170 different places of business. Thirteen hundred and thirty-six brands of feeding stuffs have been registered and permits for sale issued.

There have been no local prosecutions, but in several instances samples of interstate shipments have been taken and forwarded to the Bureau of Chemistry at Washington for examination and prosecution if the evidence warranted.

The cottonseed meal situation during the past season has been most discouraging for the feeder. Never before has the general quality of the meal been as poor nor the price as high. The poor quality has been due, in part, to the fact that practically all of the lint has been removed from the seed and used for the manufacture of gun cotton. The removal of the lint prevents the hulls from matting together, and allows them to slip through the sieves during the process of separating hulls and kernels, thus increasing the proportion of hulls in the meal and materially reducing the protein content.

At the present time (December, 1916) the price of commercial feeding stuffs has reached what is probably the highest

point known since the use of out-of-the-State feeding stuffs became general. This fact renders the wise selection of commercial feeding stuffs imperative, and also fully justifies the increase in price asked for milk and dairy products.

The following table illustrates the extreme increase in price of feeding stuffs during the past year. Average wholesale prices of November, 1915, are compared with average prices for the first two weeks of November, 1916: —

	November, 1915.	Nov. 1 to 15, 1916.	Percentage Increase.
Cottonseed meal,	$36 25	$44 50	22.7
Linseed meal (new process and old process),	39 25	44 17	12.5
Gluten feed, sacked,	27 00	39 90	47.7
Gluten feed, bulk,	25 83	37 71	45.9
Flour middlings, red dog,	30 50	44 50	45.8
Standard middlings,	25 89	38 09	47.1
Mixed feed,	26 88	36 17	34.5
Bran, spring,	23 06	31 75	37.6
Bran, winter,	23 31	32 66	40.1
Hominy meal, sacked,	28 61	43 32	51.4
Hominy meal, bulk,	26 89	40 57	50.8
Corn meal,	29 40	45 20	53.7
Oats, No. 2, clipped white,	27 81	40 63	46.0
Feed barley, standard,	26 77	42 71	59.5

(*b*) *The Dairy Law* (*Acts and Resolves for 1912, Chapter 218*).

(1) *Examination for Certificates.* — Thirty-eight applicants have been examined and found proficient.

(2) *Inspection of Glassware.* — Five thousand one hundred and eighty-four pieces of Babcock glassware have been tested for accuracy, of which only five pieces were condemned.

Following is a summary for the last sixteen years: —

Year.	Number of Pieces tested.	Number of Pieces condemned.	Percentage condemned.
1901,	5,041	291	5.77
1902,	2,344	56	2.40
1903,	2,240	57	2.54
1904,	2,026	200	9.87
1905,	1,665	197	11.83
1906,	2,457	763	31.05
1907,	3,082	204	6.62
1908,	2,713	33	1.22
1909,	4,071	43	1.06
1910,	4,047	41	1.01
1911,	4,466	12	.27
1912,	6,056	27	.45
1913,	6,394	34	.53
1914,	6,336	18	.28
1915,	4,956	4	.08
1916,	5,184	5	.10
Totals,	63,078	1,985	3.15[1]

[1] Average.

(3) *Inspection of Machines and Apparatus.* — During the month of November Mr. J. T. Howard, the authorized deputy, inspected the machines and apparatus in 87 milk depots, creameries and milk inspection laboratories. The apparatus, with few exceptions, was found to be in good working condition. In the few cases where repairs were necessary reinspections will be made.

The use of hand machines in some of the milk inspectors' laboratories is not to be commended. While accurate work can be accomplished with such machines, they make the inspector's work increasingly difficult.

Following is a list of creameries, milk depots and milk inspectors' laboratories visited in 1916: —

1. *Creameries.*

Location.	Name.	Manager or Proprietor.
1. Amherst,	Amherst,	R. W. Pease, proprietor.
2. Amherst,	Fort River,[1]	E. A. King estate, proprietor.
3. Ashfield,	Ashfield Co-operative,	Wm. Hunter, manager.
4. Belchertown,	Belchertown Co-operative,	M. G. Ward, manager.
5. Cummington,	Cummington Co-operative,	D. C. Morey, manager.
6. Easthampton,	Hampton Co-operative,	W. S. Wilcox, manager.
7. Monterey,	Berkshire Hills Co-operative,	F. A. Campbell, manager.
8. Northfield,	Northfield Co-operative,	C. C. Stearns, manager.
9. Shelburne,	Shelburne Co-operative,	W. C. Webber, manager.

[1] Testing done at the Massachusetts Agricultural Experiment Station.

2. *Milk Depots.*

Location.	Name.	Manager.
1. Boston,	Acton Farms Milk Company,	Wm. Mulcahey.
2. Boston,	Boston Jersey Creamery,	T. P. Grant.
3. Boston,	Deerfoot Farms,	Wm. Johnson.
4. Boston,	Elm Farm Milk Company,	J. K. Knapp.
5. Boston,	H. P. Hood & Sons,	N. C. Davis.
6. Boston,	Llanwhitkell Farms,	N. C. Cook.
7. Boston,	Morgan Bros.,	A. G. Johnson.
8. Boston,	Oak Grove Farm,	J. Alden.
9. Boston,	Plymouth Creamery Company,	W. J. Gardner.
10. Boston,	Rockingham Milk Company,	L. G. Sanford.
11. Boston,	Turner Centre Dairying Association,	C. E. Small.
12. Boston,	D. Whiting & Sons,	J. K. Whiting.
13. Brockton,	Brockton Public Market,	A. R. Greenwood.
14. Cambridge,	C. Brigham & Son,	J. K. Whiting.
15. Conway,	H. P. Hood & Sons,	L. E. Jones.
16. East Watertown,	Lyndonville Creamery Association,	H. H. Smith.
17. Everett,	Francis E. Boyd,	F. E. Boyd.
18. Everett,	Hampden Creamery,	R. T. Mooney.
19. Lawrence,	Jersey Ice Cream Company,	J. N. Gurdy.
20. Lawrence,	Turner Centre Dairying Association,	F. M. Barr.
21. Lawrence,	Williardale Creamery,	F. H. Williard.
22. North Adams,	Ormsby Farms,	W. E. Penniman.

2. *Milk Depots* — Concluded.

Location.	Name.	Manager.
23. Sheffield, ...	Willow Brook Dairy, ...	F. B. Percy.
24. Springfield, ...	Tait Bros., ...	H. Tait.
25. Southborough, . . .	Deerfoot Farms, ...	S. H. Howes.
26. Waltham, ...	Manhattan Creamery, . . .	L. Fontaine.
27. West Lynn, ...	H. P. Hood & Sons, ...	N. C. Davis.

3. *Milk Inspectors.*

Location.	Milk Inspector.	Location.	Milk Inspector.
1. Adams, . . .	A. G. Potter.	24. Millbury, . . .	F. A. Watkins.
2. Amherst, . . .	P. H. Smith.	25. New Bedford, . .	H. B. Hamilton.
3. Arlington, . .	L. L. Pierce.	26. Newton, . . .	A. Hudson.
4. Attleboro, . .	S. Fine.	27. North Adams, . .	C. T. Quackenbush.
5. Barnstable, . .	G. T. Mecarta.	28. Northampton, . .	G. R. Turner.
6. Boston, . . .	J. O. Jordan.	29. Pittsfield, . . .	B. M. Collins.
7. Brockton, . .	G. Bolling.	30. Plainville, . .	J. J. Eiden.
8. Cambridge, . .	W. A. Noonan.	31. Plymouth, . .	W. E. Briggs.
9. Chelsea, . . .	W. S. Walkley.	32. Revere, . . .	J. E. Lamb.
10. Chicopee, . .	C. J. O'Brien.	33. Salem, . . .	J. J. McGrath.
11. Clinton, . . .	G. L. Chase.	34. Somerville, . .	H. E. Bowman.
12. Framingham, . .	F. S. Dodson.	35. South Hadley, .	G. F. Beaudreau.
13. Everett, . . .	E. C. Colby.	36. Springfield, . .	S. C. Downs.
14. Fall River, . .	H. Boisseau.	37. Taunton, . . .	L. C. Tucker.
15. Fitchburg, . .	J. F. Bresnahan.	38. Waltham, . .	C. M. Hennelly.
16. Gardner, . . .	H. O. Knight.	39. Ware, . . .	F. E. Marsh.
17. Greenfield, . .	G. P. Moore.	40. Watertown, . .	E. J. Johnson.
18. Haverhill, . .	H. L. Conner.	41. Wellesley, . .	W. A. Berger.
19. Holyoke, . . .	D. Hartnett.	42. Westfield, . .	W. Porter.
20. Lawrence, . .	J. H. Tobin.	43. West Springfield, .	J. A. Morrill.
21. Lowell, . . .	M. Marster.	44. Winchendon, . .	G. W. Stanbridge.
22. Lynn, . . .	H. P. Bennett.	45. Woburn, . . .	D. F. Callahan.
23. Malden, . . .	J. A. Sanford.	46. Worcester, . .	G. L. Berg.

4. Miscellaneous.

Location.	Name.	Manager.
1. Boston,	Walker-Gordon Laboratory,	B. W. Nichols.
2. Boston,	United Drug Company,	J. H. Lane, chemist.
3. Boston,	Boston Laboratories,	F. Joyner.
4. Greenfield,	Franklin County Farm Bureau,	Miss M. Howard.
5. Springfield,	Emerson Laboratory,	H. C. Emerson,

(c) *Milk, Cream and Feeds for Free Examination.*

Six hundred and seventy-nine samples of milk, 852 samples of cream, 2 samples of ice cream, 204 samples of feeding stuffs, 21 samples of bread and 13 samples of vinegar were analyzed. While it is desired to be of the greatest service to residents of the State, the resources of this department are limited; hence the right is reserved to refuse to make analyses where samples are improperly drawn, where the work does not appear to be of general interest, or where it would apparently serve no useful purpose.

(d) *Water.*

Seventy-one samples of water were analyzed. This is 19 less than for the preceding year, presumably due to the fact that no serious period of drought was experienced, which tends to increase disagreeable tastes and odors in domestic water supplies.

A charge of $3 per sample is made for water analysis, and samples must be shipped in containers furnished by the experiment station. This charge is made to cover the cost of the analysis, and to serve as a restraining influence in the indiscriminate submitting of samples where the analysis would serve no useful purpose.

(e) *Testing of Pure-bred Cows for Advanced Registry.*

Four men have been given regular employment in conducting yearly tests of Jersey, Guernsey and Ayrshire cows. These tests require the presence of a supervisor at each farm where cows are under test for at least two days in each month. Three

hundred and sixty-four cows are now on test at 43 different farms. This is an increase of 114 cows over the number on test a year ago. One hundred and twenty-eight of the cows are Jerseys, 193 Guernseys and 43 Ayrshires. There have been completed during the year 200 Guernsey, 114 Jersey, 40 Ayrshire and a few Holstein tests.

The Holstein breeders usually test for seven or thirty-day periods, and require the presence of a supervisor during the entire test, although there is a provision for yearly work in the Holstein rules. The latter work, however, is in slight demand in Massachusetts; only one farm in addition to the Massachusetts Agricultural College is conducting such tests. During the year 26 different men have been employed on these shorter tests; and 201 seven-day, 41 thirty-day, and 21 fourteen-day tests have been completed. In addition, one cow owned by the Fred F. Field Holstein Company has been tested for three hundred and sixty-six consecutive days.

At times the station has been asked to permit cow test associations, which are under the supervision of county farm bureaus, to conduct advanced registry work. It is felt that for the best interest of all concerned it is not wise to follow this procedure, and our position has been endorsed by the Association of Dairy Instructors who, at their meeting held in Springfield during the National Dairy Show, voted unanimously against such a practice.

(*f*) *Miscellaneous Chemical Work.*

This section has analyzed 230 samples of milk and 175 samples of cattle feeds in connection with experiments in animal nutrition. Several hundred samples of milk have been analyzed for the dairy department in connection with dairy shows and milk contests. Thirty-seven samples of slum gum (the residue left from the extraction of beeswax from honeycomb) have been tested for the station apiarist in order to ascertain the efficiency of different methods for the extraction of beeswax from honeycomb. This section has also co-operated with other departments of the college in planning and furnishing material for an exhibit at the National Dairy Show in Springfield.

4. Numerical Summary of Laboratory Work, December, 1915, to December, 1916.

There have been received and tested 71 samples of water, 679 of milk, 852 of cream, 2 of ice cream, 4 of milk serum, 204 of feedstuffs, 197 of fertilizer, 273 of soil, 20 of lime products, 37 of slum gum, 6 of organic substances for arsenic, 13 of vinegar, 2 of coal, 4 of lime-sulfur, 2 of arsenate of lead, 1 of cider for alcohol, 21 of bread and 15 miscellaneous.

The fertilizer control work involved the collection of 1,398 samples; and the feed control, 1,109 samples. There have also been examined, in connection with experiments made by the different departments of the station, 230 samples of milk; 175 of cattle feed; ash analysis of 8 samples of corn grain, 8 of cob, 4 of stover, and 6 of cow horn turnips; dry-matter determinations and total weights were made on 260 samples of millet straw and on 260 of millet seed; 40 samples of the millet were analyzed for nitrogen and potash, 19 for nitrogen and phosphoric acid, 12 for nitrogen, potash and phosphoric acid, and 42 for nitrogen alone; and 48 samples of subsoil for potash and mechanical analysis. The above totals 6,022 samples, and does not include the work of the research section, cow testing or the work under the dairy law.

DEPARTMENT OF ENTOMOLOGY.

H. T. FERNALD.

The entomological work of the experiment station has followed along its usual lines during 1916. No unusual outbreaks of insects have appeared, the correspondence — which generally indicates what is happening in the State — having been quite diversified in its nature.

Over 2,500 letters were answered during the year. Inquiries about 149 different kinds of insects; 38 about insecticides; 19 about publications on insects; 6 on fumigation; and 52 about the best methods of controlling pests other than insects were received.

The insects most frequently asked about were, in order of frequency, plant lice, the bean weevil, ants, the white pine weevil (perhaps because of the interest in the pines aroused by the campaign against the white pine blister), the gypsy moth, the red-humped apple-tree caterpillar.

A number of insects not often reported were also the subjects of inquiry during the year, chief among these being the carrot rust fly (*Psila rosæ* Fab.), the grape plume moth, the pear midge, the oriental moth and the tarnished plant bug, which was reported as having caused serious trouble by "stinging" on the eyes and hands of the sender. Aquatic dipterous larvæ collected in a milk can were also received during the year.

For several years insects found on imported nursery stock by the State inspectors have been sent to this department for identification when not recognized by the inspector. Many such specimens are received each year, and our collection of foreign insects liable to reach this country at any time is now quite large. Nearly fifty different kinds of insects were received from the State inspectors during 1916, including several which may safely be termed potentially serious pests. While

the identification of these specimens required considerable time in some cases, the importance of the knowledge thus gained is so evident as a necessary working knowledge for a department dealing with the insect life both already present and liable to appear in the State as to make it well worth while.

Last year the ravages of the strawberry crown girdler (*Otiorrhynchus ovatus* L.) in a forest nursery were recorded at some length, the loss caused being large, the outbreak novel in its nature and the subsequent possibilities serious. During 1916, therefore, conditions were followed as they became evident, and at the close of the season the following summary of the situation for the season was obtained from the local manager of the nursery, Mr. C. C. Bray.

There was no direct loss from the attacks of these insects, though they were present to some extent and were seen during the spring digging and transplanting season. The beetles could be found during the summer, but did not gather under the trap boards as in 1915, perhaps because of much dark, damp weather. In one block next to one of those seriously injured in 1915 larvæ are known to be present now (January, 1917) but not as abundantly as in the block adjoining, a year ago.

From these and other statements available it seems probable that the period of extensive destruction by this insect is drawing to an end at this place, and that the methods of treatment advised were at least to a large degree successful in checking further injury. The initial loss was of course large, but had been practically all caused before the nature of the trouble was known and assistance asked.

The experimental work of the year has been carried on as usual. Treatments for the control of the onion maggot were a failure, there being not enough maggots present to give the experiments any value. Progress along the other lines of investigation has been satisfactory, when the large amount of routine work done by the department but really belonging to the extension service is taken into consideration.

DEPARTMENT OF HORTICULTURE.

F. A. WAUGH, J. K. SHAW AND F. C. SEARS.

The more scientific and thoroughgoing investigations in this department are being carried on by Dr. Shaw, whose report follows: —

The most important activity of the year has been the development of a root and scion investigation. In this work we have the experiment orchard practically all set, and it comprises approximately 1,100 trees. We have also about 3,600 other trees on known roots which are held in reserve for replacing vacancies in the orchard and for other work in connection with this investigation.

The work of isolating pure races in squashes with the view of securing strains which will breed true to type has been pursued with about the same result as has attended the work in previous years.

The work of observing climatic conditions with respect to fruit growing has been continued, and the equipment has been transferred from western Franklin to eastern Hampden County, where it has been placed about the peach district of Wilbraham and Hampden. There has been added to this work the idea of observing winter temperatures in relation to peach bud killing.

The most important new development in the investigation work has been the establishment of the pruning orchard, comprising some 700 trees, in which we plan to carry on some experiments in pruning trees, with particular reference to head formation.

Professor Sears, the pomologist of the department, makes the following report on a number of experiments in practical orcharding which are being carried on under his direction: —

1. An investigation into the effects of the continued use of oil as a spray material for apple orchards. The use of oil in

combating the San José scale has been very general in the past, and some growers have thought that they had injured their trees in this way. In this experiment we have a block of trees which has been sprayed with oil each year since 1909, as against one sprayed from 1909 to 1911, inclusive, and not since then, and another sprayed from 1909 to 1913 and not since.

2. Experiments were begun in 1916 to test the effect of lime-sulfur at the strength that is usually used on dormant trees, but applied in the late spring after the buds have begun to start. The object of this was twofold, — first, to note its effect on the expanding leaves, and second, to control the aphis. There was practically no damage to the leaves, although the last application was made after the blossom buds had begun to show pink, and the spray materially reduced the number of aphids. The work will be continued in 1917.

3. The department has been gradually extending its variety plantations until it now has the following numbers of varieties in the different fruits: —

Apples,	132	Blackberries,	15
Pears,	44	Currants,	19
Peaches,	40	Gooseberries,	12
Plums,	30	Raspberries,	15
Nuts,	12	Strawberries,	20
Grapes,	50	Cherries,	35

While the evidence in regard to the value of some of these is by no means conclusive, yet in many cases we already have sufficiently definite results to say whether or not they are of value to Massachusetts fruit growers.

4. The department has several plantations of dwarf trees, especially apples, which are beginning to give some very interesting results. It seems very evident that the large, or doucin, dwarf in particular may have a very distinct value in Massachusetts fruit growing. It would, of course, be especially suited to home plantations, but also seems promising, at least as a filler, in commercial plantations. The following varieties have been noticeably successful in this stock: —

McIntosh.	Jonathan.
Wealthy.	Baldwin.
Fall Pippin.	King.
Grimes Golden.	Fameuse.
Oldenburg.	Twenty Ounce.

The Jonathan trees came into bearing at three and four years, and have borne continuous crops ever since. The McIntosh, while coming in a little later, has also produced continuous and very bountiful crops, six trees producing at eight years thirty boxes, or an average of five boxes. The other varieties mentioned have been almost equally successful.

5. To test the practicability and commercial value of very close planting in orchards, a block of apple trees was set in 1912 at 10 feet each way, using Wealthy, Wagener and Oldenburg. These varieties lend themselves naturally to such a use, as they are all relatively small-growing and early-bearing trees. The trees are coming into bearing nicely, and the results already seem to indicate that the plan has distinct value. We have not yet reached the stage where the trees begin to crowd each other and therefore need to be headed in severely, which will be the most difficult stage of the work, but it is believed that with the plans we have in mind for pruning and culture these trees can be handled profitably for many years.

6. Since the autumn of 1910 work has been carried on in the renovation of an old apple orchard, on land at that time under lease but which has since been purchased by the college. The block includes about 4 acres with 92 trees on it, and at the time work was started it had been continuously neglected for many years. The land has been plowed, cultivated and fertilized regularly since the work was undertaken, and several types of pruning have been practiced on the trees according to the condition of their tops. The net result has been that this orchard has been changed in the course of six years from a state of absolute neglect, with the trees yielding nothing but cull apples, and not many of these, to a thrifty and prolific block of trees, many of which are almost models in shape, and, barring the heavy trunks and large scars where branches have been removed, might easily be mistaken for trees twenty years of age. What has been done in this block might be done with

many thousands of trees in this State if similar methods were used.

7. Several methods of handling the soil in orchards have been under investigation for some time. There are, first of all, blocks under sod culture with adjoining blocks under cultivation. Then in the cultivated sections various crops and combinations of crops are being compared as covers. The list includes the following: —

Buckwheat.
Summer Vetch.
Winter Vetch.
Crimson Clover.
Mammoth Red Clover.
Soy Beans.
Alfalfa.
Barley.
Canada Field Peas.
Cow-horn Turnips.
Purple-top Turnips.
Dwarf Essex Rape.
Rye.

Several mixtures of two or more of the above were also used.

8. It seems worth while to report here a very limited experiment undertaken at the request of the manufacturers of a secret compound known as Dextrogerm. In 1915 a representative of this firm came to Amherst and treated five trees with this compound. The trees comprised a twenty-year-old Ben Davis tree which was loaded with fruit but in a very unthrifty condition; an unusually growthy Rhode Island Greening tree of the same age that bore very little fruit; a pear tree about eighteen years old which was in very bad condition: a peach tree which had been winter injured; and a young Baldwin three years set. All these trees were given identical treatment, and so far as can be judged there has been no effect whatever.

In addition to the above we are working on the following questions: —

1. The relative value of southern grown nursery stock as compared to northern grown.

2. The desirability of one-year trees as against two-year trees.

3. A comparison of various degrees of severity in pruning trees at the time of setting.

None of these experiments has progressed far enough to give definite results.

DEPARTMENT OF MICROBIOLOGY.

CHARLES E. MARSHALL.

The investigational work of this department during the past year has been greatly handicapped because we possessed no laboratory facilities. Our recent entrance into the new laboratory of microbiology has removed the difficulties with which we have had to contend in the past. We feel now that we are in excellent quarters and that our work should develop.

Dr. Van Suchtelen has pursued his soil studies preparatory to the actual undertaking of the experiments. These have now been under consideration for some months. He expects to be in a position to push this work rapidly under present laboratory conditions.

Dr. Itano has contributed, during the past year, work which has been published in Bulletin No. 167 of the Massachusetts Agricultural Experiment Station (January, 1916), entitled: "I. The Relation of Hydrogen Ion Concentration of Media to the Proteolytic Activity of Bacillus Subtilis. II. Proteolysis of Strept. Erysipelatis and Strept. Lacticus compared under Different Hydrogen Ion Concentration." The fire in the laboratory in Amherst Center interfered with further development of these investigations which he means to continue.

The De Laval research is conducted through the instrumentality of graduate assistants. Mr. Hood, who is in general charge of this work, reports very encouraging progress and the accumulation of considerable data which will eventually be of great value. Mr. Avery and Mr. Mutkekar are associated in these investigations with Mr. Hood. These gentlemen give, as understood, only part of their time to these studies.

In addition to the above, Dr. Itano has done a great deal of test work for the local board of health and the physicians of the town. These tests have had much value for the laboratory

as well as for the board of health. Dr. Itano has also prepared several hundred legume cultures for distribution in the State. Besides the test work of Dr. Itano, Mr. Hood has conducted the monthly bacterial milk count for the town of Amherst throughout the past year, and has also made the bacterial counts for 366 samples of milk offered in contest at the Farmers' Dairy Show, Amherst, the Fitchburg Dairy Show, National Dairy Show at Springfield and the Taunton Dairy Show.

These are, I believe, in brief, the main activities of the department in its relation to the experiment station during the past year.

DEPARTMENT OF POULTRY HUSBANDRY.

J. C. GRAHAM AND H. D. GOODALE.

Practically all our main projects are long-time experiments which permit only of reports of progress. In breeding for increased egg production families that are comparatively homogenous for high winter egg production, and also for very low winter egg production, were secured during the past season, 1915–16. Families having an average winter egg production superior to any yet bred appear probable on the basis of such data for 1916–17 as are at hand at this writing. Similar but less definite results were secured with annual egg production. The work on broodiness has also given families of relatively low amounts of broodiness. One of the males tested for non-broodiness is probably a homozygous recessive, and by mating him the coming season with similar females the desired strain of non-broody Rhode Island Reds should result. Similar but less definite results have been obtained in our work in producing a strain of birds of high hatchability, as evidenced by one family, all the female members of which produced eggs of superior hatching qualities.

A small portion of our accumulated data was worked over during the past season, and portions dealing with phases of egg production prepared for publication. An intensive, statistical study of broodiness in a flock of 78 Rhode Island Reds covering a period of two years was made, and the material is being prepared for publication.

The chief new item of interest is the demonstration of a distinct negative correlation between weight at first egg and age at first egg; that is, the birds that mature earliest, on the average, are smaller than those that mature late in life. It would be desirable to know the correlation between weight and egg production directly, but as our birds are hatched weekly

over a period of three months, each hatch would require the formation of a separate correlation table. The results, however, do not promise to justify all this labor. Since, however, early maturity is associated with high egg production in Rhode Island Reds, it follows that the smaller birds on the average lay more eggs than the heavier individuals.

Each chick was weighed this year at thirty days of age. Two results stand out, — first, the early-hatched chicks weigh more at this age than the late-hatched chicks; second, the chicks from some hens surpass those from others in rate of growth.

The pullets this fall have been three weeks ahead of last season in egg production. The pullets hatched in the second and third weeks of April had a mean production for November of about 8 eggs per pullet against 1.2 for last year. Moreover, several families are homogenous in respect to early maturity.

Poultry Sanitation. — It has always seemed logical to the writer, in view of our knowledge of disease and its transmission, that complete and effective isolation of chicks from hatching time to old age would eliminate parasitic diseases, since, so far as we now know, aside from *Bacterium pullorum* the chick at hatching time is free from disease organisms. The past season the experimental young stock was reared on a plot of ground half a mile from the poultry plant, and cared for by a man who had no other duties. The isolation, however, was not as complete as could be wished, since the feed room at the plant had to be used for these birds as well as the old stock. This plan, nevertheless, resulted in apparent freedom from disease and in a remarkable freedom from the larger common parasites of poultry, and in a low rate of mortality. During June and July an epidemic of severe colds and roupy conditions swept through the young stock grown at the old plant. The old stock, too, all summer long had many cases of colds and roup. The young stock, isolated as described, however, escaped entirely. In the fall the laying houses were cleaned out and carefully disinfected, and a special attendant provided for the isolated pullets. No colds have appeared at this date, January 28. Moreover, the mortality to date has been only about one-tenth as great as usual, and due to such things as cancer,

prolapses of the oviduct and accident or ruptured blood vessels, while the proportion of sickness has been a great deal smaller (practically none), being confined to the few birds that have died. That the isolation has been effective is evidenced by the development of colds in a lot of cockerels about two weeks after they were transferred from the isolated range to the old plant and allowed to mingle freely with the stock there. Other trials yielded similar results. It seems hardly possible that better proof of the effectiveness of isolation in preventing this class of diseases could be obtained without elaborate experimentation.

Work on several phases of the relation of the secondary sexual characters to the gonads has been continued. Something like 8 or 10 cockerels and 4 drakes have been successfully feminized. A series of experiments designed to secure grafts of ovaries into hemicastrated males yielded negative results. In another series of experiments the ovaries were first removed from several Brown Leghorn females, and several weeks afterwards, when the success of the operation seemed assured, as indicated by the persistent growth of male characters, the ovaries from some White Plymouth Rock chicks were implanted on the right side. All the grafts appear to have taken, as indicated by the reversion of the plumage to the female form. This type of experiment should yield results along three lines: first, effect of the foreign ovarian secretion on the plumage; second, data on the nature of broodiness, since the ovaries were from a broody race, while the hosts belong to a non-broody race; and third, data on the effect of the soma upon the germ plasm.

Mr. White began a study of linkage in fowls as his thesis, but abandoned it when he transferred to the department of botany. The results already secured are so promising that the work will be continued.

DEPARTMENT OF VETERINARY SCIENCE.

JAMES B. PAIGE.

In addition to the usual correspondence and diagnosis work that has been carried on in the department during the past year particular attention has been given to three lines of investigation and control work, as follows: —

1. Prevention of hog cholera.
2. Study of *Bacterium pullorum* infection.
3. Suppression and eradication of bacillary white diarrhœa in fowls.

1. Prevention of Hog Cholera.

During the past year there has been at the disposal of the department a herd of 75 to 150 hogs that have been fed upon garbage, — from a source, in fact, that has on two previous occasions furnished hog cholera infection to which two outbreaks of considerable extent have been traced. To protect the hogs in this herd from the infection brought to them in this garbage and from other sources, anti-hog-cholera serum and virus have been used extensively to produce a condition of artificial immunity. During a part of the year the susceptible members of the herd were treated by the simultaneous method, the "Globulin" preparation of serum supplied by the H. K. Mulford Company being used. The manifest advantage of the "Globulin" over the usual anti-hog-cholera serum is dependent upon its greater degree of concentration and its freedom from organisms that frequently occasion serious complications when injected subcutaneously or intramuscularly. For a part of the animals a refined "Amber Serum" from the Mulford Company has been employed, which, on account of its freedom from the usual blood elements and its sterility, has been found to give very satisfactory results.

2. Study of Bacterium Pullorum Infection.

During the year 1916 the project outlined in connection with the studies on bacillary white diarrhœa has been conducted along lines already established. The object of the work has been to improve methods in diagnosis, to explain reasons for symptoms in certain avian diseases at present but little understood, and to aid in formulating methods in prevention and control.

The problem by nature of the biological phases of the work is divided into three distinct parts, which are stated in the following three headings: —

(1) Specificity of *B. pullorum* antibodies, with special reference to the agglutinins.

(2) Toxins elaborated by *B. pullorum* and their relation to specific conditions in adult birds.

(3) Investigations concerning the production of antibodies, with special reference to potency and rate of production.

(1) The work concerning the specificity of *Bacterium pullorum* agglutinins has been continued since 1915, and tests and procedures carried along concerning the use of 27 strains of this organism isolated from birds in this State. Recently more than 10 new strains have been added to this list. The data obtained and that being accumulated will have to do with testing thoroughly the agglutinins elaborated by animals and birds against *B. pullorum*, with cultures particularly of the *B. coli*, *B. typhi*, *B. dysenteræ* group. By the end of the academic year 1917 it is hoped that this phase of the *Bacterium pullorum* problem will be ready for publication. At the present time 21 adult birds are immunized against *B. pullorum*, and are producing definite agglutinins. Fourteen rabbits also are used for these studies, having been immunized and hyperimmunized during the past year.

(2) The problem concerning the production of toxin by *B. pullorum* has engaged most of the time at my disposal for experiment station work during the past ten months. This is proving a most complicated and detailed matter for study, and has involved almost endless detail concerning the matter of obtaining a uniform toxin. Up to the present time a toxin

which is suitable for carrying on progressive work has not been found. Definite studies, however, are under way toward this end. With the spring months approaching, and suitable weather and conditions for hatching and rearing chicks drawing near, it is expected that with young and new materials to work on more definite results may be obtained. The results up to date show beyond a doubt that the toxin is endotoxic, and also that it is most intimately connected with the bacterial cell. Our toxin studies are being directed toward a better understanding of the nature of this infection, and ultimately the department hopes from these studies to explain its action in relation to some of the paralytic conditions in adult birds, which in the last few years have been so common in the State of Massachusetts.

(3) The investigation concerning the production of antibodies, with special reference to the potency and rate of production, was started in August, 1916, and agglutinins artificially produced. Blood from this stock has been studied, and now attempts are being made to study the progeny this year to determine how potent are agglutinins elaborated in birds descended from stock known to have definite infection experimentally produced. These studies are to be continued, with the hope that we may be able to show the rate of production, and demonstrate why young pullet blood testing has not given as universally satisfactory results as the blood testing of birds that have laid eggs and have ovaries capable of complete function. This problem has direct bearing on the routine work of testing breeding flocks for indications of *Bacterium pullorum* infection.

3. Suppression and Eradication of Bacillary White Diarrhœa in Fowls.

In the prosecution of this line of control work every effort has been made to carry it on in the most practical way, looking toward the elimination of the disease from the flocks of practical poultry keepers. The laboratory studies have shown the test to be most accurate and reliable, and the testing that has been done in the field since the work was started has been entirely satisfactory. It is felt that the disease has been com-

pletely stamped out of the flocks that have been tested during the past two years, and in which the directions for the handling of the flocks have been carried out to the letter by their owners. If there have been failures and a recurrence of the disease it has been due to neglect in following the directions that have been given the owners.

Since the work was started in a practical manner in February, 1915, 14,851 birds have been tested to Jan. 1, 1917. Of this number 2,207 have given the reaction. The tested flocks are owned by 78 different parties residing in 57 different towns scattered throughout the State.

REPORT OF CRANBERRY SUBSTATION FOR 1915.

BY H. J. FRANKLIN.

The season's studies followed chiefly the lines of previous years, but more extensive storage experiments were conducted with the fruit than heretofore, and considerable attention was given to the possibility of growing selected varieties of the swamp blueberry (*Vaccinium corymbosum* L.) on bogs where cranberries do not pay, somewhat more than half an acre of land having been partially prepared to test the feasibility of this substitution.

It is hoped that Massachusetts cranberry growers will give special consideration to the new ideas suggested in the discussion of bog management. They are advanced, not as established principles, but as possibilities which, in the light of general experience and the results of several years of extensive investigation, appear to be promising.

Weather observations were carried on as in previous seasons, the readings of the maximum and minimum thermometers and the amounts of precipitation being telegraphed to the Boston office of the United States Weather Bureau during the periods of frost danger, and advice concerning temperature possibilities being given by telephone to individual growers on cold nights when asked for.

Experiments with tobacco shade cloth for frost protection were continued, with the general result that its use for this purpose appears less advisable than the 1914 tests seemed to indicate, the difficulties connected with its manipulation on the bog evidently being considerable. The cloth should be given further trial, however. There is as yet no other promising means of protection for many dry bogs, but the total acreage of such bogs is small. In the present opinion of the writer, a cheaper and more certainly effective means of protection may be had on most unprotected bogs by properly conserving and manipulating (by means of small pumping plants, the bog areas being more extensively divided by low dikes) the water of the winter flowage (see the more extended discussion of this idea on page 46).

Fungous Diseases.

These studies were carried on, as heretofore, in co-operation with the Bureau of Plant Industry of the United States Department of Agriculture, Dr. C. L. Shear having charge of the more technical part of the work.

Table 1 is a record of the season's experience with the spraying plots, experiments with which have been reported in previous years. Plots C and E were left without treatment as in 1914, and only one-half of plots B and D were sprayed this year. As in 1914, Bordeaux mixture (with resin fish-oil soap) was the only fungicide used, the final spraying with neutral copper acetate applied in former years being omitted. The different areas treated this year were sprayed as follows: plot A, three times, on June 28, July 24 and August 7; half of plot B, three times, on June 28, July 28 and August 9; half of plot D, three times, on June 29, July 19 and August 7; "1913," three times, on June 28, on July 15 and 24 (half of the plot treated on the former date and half on the latter) and on August 9; half of fertilizer plot 15, three times, on June 28, July 18 and August 7. No fertilizer was applied to any of these plots, except the half of fertilizer plot 15, this season. All the plots were picked with scoops as usual. Where two checks were taken they were laid out on opposite sides of the plot, and their areas and fruit production were combined in making up the record given in Table 1.

TABLE 1. — *Results of Spraying for Fungous Diseases.*

PLOT.	Whether sprayed in 1915 or not.	Area of Plot (Square Rods).	Variety.	Date picked.	Quantity of Fruit obtained (Bushels).	Quantity of Fruit per Square Rod (Bushels).	Quantity of Fruit placed in Storage Tests (Bushels).[1]	Period of Storage Test.	Method of Examination for Rot Percentage.[2]	Per Cent. of Loss by Rot in Storage Test.
A (middle portion),	Sprayed.	8	Late Howe.	Oct. 13	2.75	.344	2.75	Oct. 13 to Jan. 8	Five-sample.	11.25
A (side strips),	Sprayed.	8	Late Howe.	Oct. 13	1.75	.219	1.75	Oct. 13 to Jan. 7	Five-sample.	7.48
A (2 checks),	Not sprayed.	13	Late Howe.	Oct. 13	11.81	.908	5.00	Oct. 13 to Jan. 8	Five-sample.	13.89
B (part sprayed in 1915),	Sprayed.	7 1/10	McFarlin.	Oct. 13	2.33	.330	2.33	Oct. 13 to Jan. 6	Five-sample.	6.29
B (part not sprayed in 1915),	Not sprayed.	7 1/10	McFarlin.	Oct. 13	3.07	.435	3.00	Oct. 13 to Jan. 7	Five-sample.	19.05
B (1 check),	Not sprayed.	13 3/5	McFarlin.	Oct. 13	10.83	.793	4.00	Oct. 13 to Jan. 7	Five-sample.	12.60
C,	Not sprayed.	16	Late Howe.	Oct. 14	1.60	.100	1.50	Oct. 14 to Jan. 5	Five-sample.	11.29
C (2 checks),	Not sprayed.	16	Late Howe.	Oct. 14	3.70	.231	3.00	Oct. 14 to Jan. 7	Five-sample.	8.90
D (part sprayed in 1915),	Sprayed.	8	Early Black.	Sept. 22	3.40	.425	4.00	Sept. 22 to Jan. 3	Five-sample.	17.06
D (part not sprayed in 1915),	Not sprayed.	8	Early Black.	Sept. 22	5.00	.625	4.00	Sept. 22 to Jan. 5	Five-sample.	33.41
D (1 check),	Not sprayed.	12	Early Black.	Sept. 22	13.75	1.146	4.00	Sept. 22 to Jan. 5	Five-sample.	28.63
E,	Not sprayed.	16	Early Black.	Sept. 22	7.33	.458	–	– –	– –	–
E (1 check),	Not sprayed.	12	Early Black.	Sept. 22	6.83	.569	–	– –	– –	–
"1913,"	Sprayed.	9	Late Howe.	Oct. 14	2.40	.267	–	– –	– –	–
"1913" (2 checks),	Not sprayed.	6	Late Howe.	Oct. 14	1.67	.278	–	– –	– –	–
Sprayed half of fertilizer plot 15,	Sprayed.	4	Early Black.	Sept. 16	2.50	.625	2.33	Sept. 16 to Jan. 6	Five-sample.	24.22
Other half of plot 15,	Not sprayed.	4	Early Black.	Sept. 16	3.33	.833	3.33	Sept. 16 to Jan. 6	Five-sample.	27.33

[1] All this fruit was stored in bushel crates.

[2] See the general discussion of this season's storage tests (p. 6).

It will be seen that the results with these plots were entirely in line with the experience of former years, the quantity of fruit obtained from the sprayed areas being in every case distinctly less than that produced by the untreated checks. Moreover, the plots which had been treated for several years, and on which the spraying was suspended in 1915, also yielded distinctly less fruit than their checks, thus showing a marked persistence of the results of the injury caused by the treatment. The results of the storage tests show the same benefit from the spraying, as regards its effect on the keeping quality of the berries, as that obtained in previous seasons. It should be observed, however, that in every case tested, the berries from the areas on which the treatment of previous years was suspended showed poorer keeping quality than did those from their checks which had never been treated. This seems to show that the good results obtained by spraying do not persist from one year to another.

The possibility of controlling fungous diseases by putting copper sulfate in the flowage was tested again this season, a solution of the chemical being used in the June reflow on flooding sections 23 and 27 (of station bog) at the rate of 1 part to 50,000 parts of water (1 pound in 6,250 gallons). The treatment was applied June 17, after these sections had been completely flooded for fifteen hours, and the water was then held twenty-nine hours longer. An even distribution of the chemical was obtained by constantly dragging it around in a sack in the water as it dissolved. The blossom buds were well developed, but they did not show any injury from the treatment. Both the treated and untreated flooding sections were picked with scoops on September 17, the former showing no advantage in the quantity of fruit obtained. In storage tests, however, the berries from the treated sections showed smaller percentages of rot than did those from the other sections, though the advantage apparently obtained was not great enough to be especially gratifying. These results are similar to those obtained in 1914. They are shown more in detail in the following table: —

TABLE 2. — *Effect of Treatment with Copper Sulfate in June Reflow.*

Flooding Section.	Variety.	Area of Section (Square Rods).	Quantity of Fruit picked (Bushels).	Quantity of Fruit per Square Rod (Bushels).	Period of Storage Test.	Quantity of Fruit stored (Bushels).	Loss by Rot in Storage Test (Per Cent.).	Method of Examination for Rot Percentage.
21	Early Black.	21.30	9.50	.446	Sept. 17 to Jan. 3	4	23.75	Five-sample.
23[1]	Early Black.	12.80	3.35	.262	Sept. 17 to Jan. 3	3	21.74	Five-sample.
25	Early Black.	11.60	3.43	.296	Sept. 17 to Jan. 3	3	35.44	Five-sample.
27[1]	Early Black.	10.66	5.23	.491	Sept. 17 to Jan. 5	4	19.57	Five-sample.
29	Early Black.	10.61	7.85	.740	Sept. 17 to Jan. 7	4	24.78	Five-sample.

[1] Treated.

The special tests with Bordeaux mixture, made up with varying proportions of lime and copper sulfate, both with and without resin fish-oil soap, to determine the causes for the root injury observed, as described in previous reports, in connection with the spraying experiments have been continued and extended, but have not yet advanced far enough to give definite results.

The writer visited the New Jersey cranberry growing section in July, and examined bogs there which had been sprayed regularly with Bordeaux mixture for several years. The last treatment of the season was being applied at the time. No indication of any such injury as that caused in the spraying tests conducted by the writer at East Wareham was seen. The reason for the difference in the results of this treatment on Cape Cod and in New Jersey is not yet evident. It may be connected in some way with the fact that on most New Jersey bogs sand is not used for a surface mulch as in Massachusetts. Results seem to amply justify spraying with Bordeaux mixture to control cranberry fungous diseases in New Jersey, but this treatment is distinctly on probation on Cape Cod bogs.

The disease spoken of as "Wisconsin false-blossom" in the 1914 report of the substation was discovered this season on Metallic Bell and Bennett Jumbo vines on a bog in Wareham, the infestation being very serious with both varieties. These vines came originally from City Point and Mather, Wis., and had been planted on the Wareham bog about four years. Early in July this disease was reported by Miss Elizabeth C. White as being present on Bennett Jumbo vines on a bog belonging to her father near New Lisbon, N. J., these vines having come from Wisconsin in May, 1908. She stated that from 5 to 10 per cent. of the blossoms on these vines were affected, and that the disease had also been found, to some extent, on "Centennial vines in the same and adjoining bogs." Some time afterward the writer visited these bogs and succeeded in finding a few vines which showed plainly the effects of the disease, though the area planted to the Bennett Jumbo variety had then been burned over. It will be seen that evidence tending to prove the disease infectious is accumulating. Special studies to determine this point have been started. Vines of the Berlin Bell variety, which came originally from Wisconsin, growing on bogs in Bourne and Plymouth, were examined carefully late in June, but no trace of this disease was found upon them.

The new disease, called the "blossom-end rot" in previous reports, appeared to be distinctly less prevalent than usual this season, the fruit of the Late Howe variety, as a rule, keeping unusually well. Dr. Shear is continuing his technical investigation of the fungus which causes this disease.

Storage Tests.

As a part of the fungous disease investigation, extensive storage tests were conducted during the fall and early winter to determine the effects of some of the factors affecting the keeping quality of cranberries. The descriptions of all of these tests that gave results of any considerable

interest or value are arranged in groups, according to the purposes of the tests, in the following list.

(*a*) *To determine the General Relationship of Ventilation* (*Relative Humidity*) *to the Rate of Decay.* — The five distinct series of tests under this head were as follows: —

1. Eighty-four bushels of Early Black berries (4 bushels from each of the 21 fertilizer plots) were stored in bushel picking crates (with slatted bottom and sides) right after they were picked, just as they came from the bog (*i.e.*, without being run through the separator or otherwise cleaned). Table 3 shows the results of this series of tests in detail. Plots 1 and 2 were picked on September 14; 3 to 20, inclusive, on September 16; and 21, on September 17.

For the first month these boxes were stacked in the basement of the station screen-house without regard to order, but during the rest of the storage period the four from each plot were placed in a stack by themselves.

Cup samples were taken for making the examinations by which the counts, summaries of which are given in Table 3, were obtained. The cup used was the inspectors' cup of the New England Cranberry Sales Company, and the examinations were made, under the writer's supervision, by the "screeners" who had been employed at the station during the fall, New England Cranberry Sales Company's inspectors' hand-graders being used to facilitate the work. The dates of these examinations ranged from January 3 to January 7, inclusive. As indicated in Table 3, entirely and partly decayed berries were counted together in determining the percentages of rot.

What is called in this report the "five-sample" method was used in making these examinations. In this method, five samples from each box were examined: one sample, Te (1) and Te (2), being taken from the top or surface berries at each end of the box; one sample, Me (1) and Me (2), being taken from the berries halfway between the top and the bottom of the box at each end; and one sample, Mm, being taken from the very center of the box.

TABLE 3. — *Relationship of Ventilation (Relative Humidity) to Rate of Decay. — Results of First Series of Storage Tests.*

PLOT.	TE (1).			TE (2).			ME (1).			ME (2).			MM.		
	Total Number of Berries in the Samples of the Four Boxes.	Total Number of Rotten and Partly Rotten Berries in the Four Samples.	Percentage of Rotten and Partly Rotten Berries.	Total Number of Berries in the Samples of the Four Boxes.	Total Number of Rotten and Partly Rotten Berries in the Four Samples.	Percentage of Rotten and Partly Rotten Berries.	Total Number of Berries in the Samples of the Four Boxes.	Total Number of Rotten and Partly Rotten Berries in the Four Samples.	Percentage of Rotten and Partly Rotten Berries.	Total Number of Berries in the Samples of the Four Boxes.	Total Number of Rotten and Partly Rotten Berries in the Four Samples.	Percentage of Rotten and Partly Rotten Berries.	Total Number of Berries in the Samples of the Four Boxes.	Total Number of Rotten and Partly Rotten Berries in the Four Samples.	Percentage of Rotten and Partly Rotten Berries.
1, ...	493	101	20.49	509	120	23.58	469	106	22.60	486	134	27.57	514	189	36.77
2, ...	448	117	26.12	474	116	24.47	432	156	36.11	461	134	29.07	489	161	32.92
3, ...	475	102	21.47	465	94	20.22	462	96	20.56	480	105	21.88	512	130	25.39
4, ...	469	116	24.73	437	107	24.49	460	126	27.34	476	125	26.26	479	126	26.30
5, ...	466	146	31.33	467	137	29.34	445	124	27.87	463	139	30.02	462	166	35.93
6, ...	475	106	22.32	460	120	26.09	482	133	27.59	467	109	23.34	513	168	32.75
7, ...	492	148	30.08	464	116	25.00	477	135	28.30	460	127	27.61	496	145	29.23
8, ...	466	111	23.82	455	119	26.15	461	109	23.64	456	123	26.97	488	136	27.87
9, ...	527	85	16.13	518	106	20.46	492	123	25.00	508	108	21.26	541	150	27.73
10, ...	505	121	23.96	498	92	18.47	496	100	20.16	481	116	24.12	476	126	26.47
11, ...	454	177	38.99	475	176	37.05	449	158	35.19	467	181	38.76	481	173	35.97
12, ...	446	130	29.15	468	107	22.86	441	133	30.16	443	123	27.77	475	160	33.68
13, ...	457	64	14.00	462	77	16.67	448	60	13.39	442	70	15.84	470	81	17.23
14, ...	425	95	22.35	460	121	26.30	452	126	27.88	435	122	28.05	464	142	30.60
15, ...	456	112	24.56	449	113	25.17	438	116	26.48	456	115	25.22	462	162	35.06
16, ...	450	94	20.89	450	100	22.22	482	99	20.54	447	84	18.57	472	123	26.06
17, ...	491	84	17.11	477	83	17.40	497	103	20.72	476	78	16.39	497	99	19.92
18, ...	465	104	22.37	478	95	19.87	456	111	24.34	445	118	26.52	479	116	24.22
19, ...	474	82	17.30	468	88	18.80	463	102	22.03	488	115	23.57	499	125	25.05
20, ...	462	116	25.11	471	129	27.39	466	137	29.40	476	138	28.99	519	180	34.67
21, ...	470	106	22.55	461	111	24.08	471	113	23.99	475	134	28.21	505	153	30.31
Averages, ...	470	110⅓	23.47	470	111	23.62	464	117½	25.32	466	119	25.54	490	143	29.24

As will be seen by comparing the percentages in the line of averages in the above table, the amount of decay in these boxes was least among the top berries and greatest among those at the center of the box; and the berries at the ends of the box, halfway between the top and bottom, showed more rot than did the surface berries, but less than did those at the center, it being self-evident that the distribution of the decay was governed largely by the ventilation to which the berries in the different parts of the box were subject. The averages of the table show further that, at the end of the test, the berries at the center of the box were considerably smaller than those in the other parts (it taking a larger number to fill the cup used in sampling), while those taken from halfway between the top and the bottom of the ends of the box were slightly larger than were the surface berries. In the opinion of the writer this variation in the size of the berries from the different parts of the box was an exhibition of the varying resultant of the combined action of the three factors which appear to be most important as causes of shrinkage in cranberry storage, namely: —

(1) Advanced Decay: Berries in this condition are thrown away in separating and screening. A marked softening and frequently a shriveling accompany the complete disintegration of the fruit tissue. Rotten berries, under even moderate pressure, will take up less room in proportion to their number than will sound ones. The variation in the percentage of such berries in the different parts of the box would, therefore, necessarily have a bearing on the relative number of berries in the samples.

(2) Incipient Decay: This is not usually superficially apparent. The hardly discernible softening and shriveling which accompanies the slight disintegration of the fruit tissue in the early stages of decay appears to be a very potent cause of shrinkage both in the size of the individual berries and in the quantity of fruit in the mass. The shriveling of berries of the Early Black variety which has been generally supposed to be caused by loss of water appears to be due to this disintegration of incipient decay. As there is an optimum temperature for the development of the fungi which cause decay, there seems to be, in connection with this kind of shrinkage, a suggestion that it may be possible to develop a heating test by which inspectors can determine the relative keeping qualities of cranberries before they are shipped.

(3) Loss of Water: It is as yet impossible to say how great the shrinkage in the size of the berries due to water loss is, but it appears to be much less than that caused by either the incipient or advanced decay described above.

It would seem that in these tests the berries halfway between the top and bottom, at the ends of the boxes, suffered less shrinkage in size because, on the one hand, they were not subject (their ventilation being less) to as much loss of water as were the surface berries, and, on the other hand, they did not develop as much decay as did those at the center, their gain from reduction in loss of water more than offsetting their greater shrinkage

from increased decay as compared with the surface berries. With the berries at the center of the box, however, the increase in incipient and advanced decay, in comparison with that of the other berries, was evidently sufficient to cause a shrinkage which the reduction in the loss of water could only partly offset.

2. Two lots, one consisting of 64 bushels (16 stacks of 4 boxes each) of Early Black berries, and the other of 36 bushels (9 stacks of 4 boxes each) of Late Howe berries, were stored as were the berries in the first series of tests. The Early Black berries were picked on different dates between the 13th and 22d of September, and the Late Howe between the 12th and 22d of October. The berries of both lots were examined during the first week in January in the same way as were those in the first series. The averages of the totals of the four counts obtained in the examination of the samples of the four boxes of each stack are given in the following table: —

TABLE 4. — *Relationship of Ventilation (Relative Humidity) to Rate of Decay. — Results of Second Series of Storage Tests.*

Lot.	Number of Bushels in Lot.	Part of Box examined.	Total Number of Berries in the Samples of the Four Boxes.	Total Number of Rotten and Partly Rotten Berries in the Four Samples.	Percentage of Rotten and Partly Rotten Berries.
		Te (1).	477¾	124	25.95
		Te (2).	496½	134¾	27.14
Early Black, . .	64 (16 stacks of 4 boxes each),	Me (1).	484¾	139¾	28.83
		Me (2).	483⅓	138	28.55
		Mm.	506	163½	32.31
		Te (1).	387½	48¼	12.45
		Te (2).	392⅔	46⅓	11.80
Late Howe, . .	36 (9 stacks of 4 boxes each),	Me (1).	380	52½	13.82
		Me (2).	385	47	12.21
		Mm.	389⅔	64	16.42

For an explanation of the lettering in the table indicating the different parts of the box examined, see the description of the "five-sample" method given above in the discussion of the first series of tests. As the figures of the table show, the results of this series of tests were entirely similar to those of the first series.

3. Thirty-nine boxes (bushel picking crates with slatted bottoms and sides), some with Early Black and some with Late Howe berries. This fruit was stored like that in the first two series of tests. It was picked on

different dates in September and October, and was examined during the first week in January by what is called in this report the "nine-sample" method. In this method nine samples from each box were examined, one sample, Te (1) and Te (2), being taken from the top or surface berries at each end of the box; one sample, Tm, from the surface berries at the middle of the box; one sample, Me (1) and Me (2), from the berries halfway between the top and the bottom of the box at each end; one sample, Mm, from the very center of the box; one sample, Be (1) and Be (2), from the very bottom of the box at each end; and one sample, Bm, from the bottom of the box at the middle. The totals of the counts of each of these samples from all of the thirty-nine boxes in this series of tests are given in the following table: —

TABLE 5. — *Relationship of Ventilation (Relative Humidity) to Rate of Decay. — Results of Third Series of Storage Tests.*

PART OF BOX EXAMINED.	Total Number of Berries in 39 Samples.	Total Number of Rotten and Partly Rotten Berries in 39 Samples.	Percentage of Rotten and Partly Rotten Berries.
Te (1),	4,352	496	11.40
Te (2),	4,358	529	12.14
Tm,	4,346	663	15.26
Me (1),	4,272	582	13.62
Me (2),	4,333	602	13.89
Mm,	4,465	910	20.38
Be (1),	4,383	520	11.86
Be (2),	4,306	551	12.80
Bm,	4,523	760	16.80

The results of this series of tests, as shown by the figures in the table, confirm those of the first two series. The berries at the bottom of the box developed less decay than those halfway between the top and bottom, and those at the middle of the box (at the top and the bottom as well as at the center) rotted more than those at the ends, this giving additional evidence that the berries most subject to ventilation decay least rapidly.

4. Two lots, one consisting of 3 bushels of Late Howe berries stored in three 1-bushel boxes, and the other of 3 bushels of berries of the same variety, picked at the same time and in the same place as those of the first lot, divided up equally among nine boxes of the same size and construction as those used for storing the first lot, their sides being slatted and their bottoms solid, all being new. This series of tests was begun on October 29, and the berries were examined on January 10; the "nine-sample" method of examination, described in the discussion of the third

series, being used with the three boxes of the first lot, and each of those of the second lot being sampled six times, one sample being taken from among the surface berries at each end of the box; one from the surface berries at the middle of the box; one from the bottom berries at each end of the box; and one from the bottom berries at the middle of the box. By this examination the percentage of decay among the berries of the three full boxes was determined to be 10.31 per cent., while it was found to be only 7.63 per cent. in the nine one-third full boxes, the berries which were subject to the better ventilation thus showing the smaller proportion of rot.

As in all the other storage tests discussed in this report, the work of examining this fruit was done by "screeners" under the writer's supervision, sampling cups and hand-graders being used as described in the discussion of the first series of tests.

5. Ninety-six tin 1-quart cans filled with Late Howe cranberries during the last week in October were stored with the covers on tight, but not sealed. These berries were examined on the 4th and 5th of January, the contents of each can being divided into five separate samples which were taken in order from the top to the bottom of the can. Each of the first four samples filled the sampling cup; but the fifth, consisting of what was left at the bottom of the can, varied somewhat and only partly filled the cup. The totals of the counts of each of these samples from all of the ninety-six cans in this series of tests are given in the following table: —

TABLE 6. — *Relationship of Ventilation (Relative Humidity) to Rate of Decay. — Results of Fifth Series of Storage Tests.*

Sample.	Total Number of Berries in 96 Samples.	Total Number of Rotten and Partly Rotten Berries in 96 Samples.	Percentage of Rotten and Partly Rotten Berries.
1,	8,784	1,751	19.93
2,	8,800	2,159	24.53
3,	8,650	2,466	28.51
4,	8,626	2,755	31.91
5,	5,595	1,875	33.51

The table shows there was a rapid and constant increase in the percentage of decayed berries from the top to the bottom in these cans. As their only ventilation took place around the close-fitting covers, it seems certain that the top berries were better ventilated than those lower down in the cans. The results of this series of tests, therefore, evidently strongly confirm those obtained in the four series previously discussed.

(*b*) *To determine the Relative Water Loss of Cranberries in Storage in*

Boxes of Different Construction and in Different Periods of the Storage Season. — The two series of tests, in this connection, were as follows: —

1. Two lots, each consisting of 6 bushels of Late Howe berries, all picked in the same location on October 22 and all stored on October 23, one lot being placed in new bushel boxes with solid bottoms and solid sides, and the other in new boxes of the same dimensions with solid bottoms and slatted sides. Tables 7 and 8 show how the tests with these two lots of fruit were arranged and carried out. The six boxes of each lot were placed in a single stack, No. 1 being the top box of the stack and No. 6 the bottom one. These berries were weighed in their boxes on October 24, when the tests were begun, on December 18, on January 3, and when the tests ended, on January 10.

TABLE 7. — *Water Loss of Late Howe Cranberries in Boxes with Solid Bottoms and Sides in Different Periods of the Storage Season.*

Box Number.	Weight (Gross) on October 24 (Ounces).	Weight (Gross) on December 18 (Ounces).	Loss in Weight between October 24 and December 18 (Ounces).	Average Daily Loss between October 24 and December 18 (Ounces).	Weight (Gross) on January 3 (Ounces).	Loss in Weight between December 18 and January 3 (Ounces).	Average Daily Loss between December 18 and January 3 (Ounces).	Weight (Gross) on January 10 (Ounces).	Loss in Weight between January 3 and January 10 (Ounces).	Average Daily Loss between January 3 and January 10 (Ounces).	Weight of Empty Box on January 10 (Ounces).	Net Weight of Berries on October 24 (Ounces).[1]	Net Weight of Berries on January 10 (Ounces).[1]	Total Loss in Weight between October 24 and January 10 (Ounces).[1]	Percentage of Weight Shrinkage (due to Loss of Water) between October 24 and January 10.
1,	758	738	20	.3636	734	4	.2500	732	2	.2857	146	612	586	26	4.25
2,	746	731	15	.2727	728	3	.1875	726	2	.2857	140	606	586	20	3.30
3,	753	738	15	.2727	734	4	.2500	733	1	.1429	138	615	595	20	3.25
4,	755	739	16	.2909	736	3	.1875	735	1	.1429	144	611	591	20	3.27
5,	740	720	20	.3636	717	3	.1875	716	1	.1429	135	605	581	24	3.97
6,	744	723	21	.3818	720	3	.1875	718	2	.2857	143	601	575	26	4.33
Averages,	749⅓	731½	17⅚	.3242	728	3⅓	.2083	726⅔	1½	.2143	141	608⅓	585⅔	22⅔	3.73

[1] The change in the weight of the boxes themselves during the storage was thought to be so small that it was neglected in making these computations. Several empty new boxes, entirely similar to those used in these tests, were weighed on October 24 and again on January 10 and were found to have lost 2 ounces each. It seems probable, however, that, when filled with berries, these boxes absorbed enough of the moisture given off by the fruit to largely offset their own loss of water. Unfortunately, this absorption, as being a possible factor of some importance, was not foreseen in planning these tests.

TABLE 8. — *Water Loss of Late Howe Cranberries in Boxes with Solid Bottoms and Slatted Sides in Different Periods of the Storage Season.*

Box Number.	Weight (Gross) on October 24 (Ounces).	Weight (Gross) on December 18 (Ounces).	Loss in Weight between October 24 and December 18 (Ounces).	Average Daily Loss between October 24 and December 18 (Ounces).	Weight (Gross) on January 3 (Ounces).	Loss in Weight between December 18 and January 3 (Ounces).	Average Daily Loss between December 18 and January 3 (Ounces).	Weight (Gross) on January 10 (Ounces).	Loss in Weight between January 3 and January 10 (Ounces).	Average Daily Loss between January 3 and January 10 (Ounces).	Weight of Empty Box on January 10 (Ounces).	Net Weight of Berries on October 24 (Ounces).[1]	Net Weight of Berries on January 10 (Ounces).[1]	Total Loss in Weight between October 24 and January 10 (Ounces).[1]	Percentage of Weight Shrinkage (due to Loss of Water) between October 24 and January 10.
1, ...	771	749	22	.4000	745	4	.2500	743	2	.2857	142	629	601	28	4.45
2, ...	759	740	19	.3455	737	3	.1875	735	2	.2857	144	615	591	24	3.90
3, ...	746	724	22	.4000	720	4	.2500	719	1	.1429	143	603	576	27	4.48
4, ...	736	717	19	.3455	713	4	.2500	712	1	.1429	142	594	570	24	4.04
5, ...	757	737	20	.3636	734	3	.1875	732	2	.2857	145	612	587	25	4.08
6, ...	758	734	24	.4364	729	5	.3125	728	1	.1429	144	614	584	30	4.89
Averages, . . .	754½	733½	21	.3818	729⅔	3⅚	.2396	728	1½	.2143	143⅓	611	585	26⅓	4.31

1 The change in the weight of the boxes themselves was not considered (see explanation in connection with Table 7, above).

The figures given in Tables 7 and 8 show that there was a much greater daily loss of water in the first part of the storage period (from October 24 to December 18) than in the last part (from December 18 to January 10). This probably was to be expected on account of the higher temperature of the first part of the storage period. The great variation in the average daily loss between January 3 and January 10, shown in the tables, was due to the fact that differences of less than an ounce were not clearly indicated by the scales used in weighing. It will be seen that the berries in the boxes with slatted sides lost, on the average, about 15 per cent. more water than did those with solid sides.

2. Three bushels of Late Howe berries, picked on October 22 in the same location as the two lots in the previous series of water-loss tests, were stored on October 23 in old and well-seasoned bushel boxes with bottoms and sides slatted. These boxes were stacked one on another, and, as in all the other storage experiments with boxes described in this report, an empty box was put underneath the stack. This test was conducted as an extension of the previous series. The berries were weighed in the boxes twice, at the beginning and at the end of the storage. The results of the test are shown in detail in the following table: —

TABLE 9. — *Water Loss of Late Howe Cranberries in Boxes with Bottoms and Sides Slatted.*

Box Number.	Weight (Gross) on October 24 (Ounces).	Weight (Gross) on January 10 (Ounces).	Weight of Empty Box on January 10 (Ounces).	Net Weight of Berries on October 24 (Ounces).[1]	Net Weight of Berries on January 10 (Ounces).	Loss in Weight between October 24 and January 10 (Ounces).	Percentage of Weight Shrinkage, due to Loss of Water, between October 24 and January 10.
1,	771	739	137	634	602	32	5.05
2,	691	661	111	580	550	30	5.17
3,	655	624	145	510	479	31	6.08
Averages,	706	675	131	575	544	31	5.43

[1] The change in the weight of the boxes themselves was not considered.

A comparison of the figures in this table with those of Tables 7 and 8 shows that the berries in these boxes lost on the average about 45 per cent. more water than those in the solid boxes and about 26 per cent. more than those in boxes with solid bottoms and slatted sides. The average amount of decay in the solid boxes was found to be 9.26 per cent., while it was only 8.19 per cent. in the boxes with sides and bottoms slatted, there being, therefore, about 13 per cent. more rot in the former boxes than in the latter. This does not show a very marked advantage, as regards their effect on keeping quality, for the slatted boxes. It should

be remembered, however, that the keeping quality of the berries used in these tests was exceptionally good. With berries of poorer keeping quality, the slatted boxes would naturally show a greater advantage.

As the figures in Tables 7, 8 and 9 show, the berries in the bottom box of each stack lost more water than did those in any of the other boxes, those in the top box as a rule coming second in this respect. The free circulation of air under the stacks, allowed by the presence of the empty box, was presumably responsible for the increased loss of the bottom box.

(*c*) *To determine the Effect of the Loss of Water as a Factor in Quantity Shrinkage.* — Only one series of tests was conducted in this connection, as follows: —

Early Black berries picked on September 11 were screened and packed in barrels on the 15th. They were then stored until October 11, when they were screened again and examined for size, counts of the number necessary to fill the inspectors' cup of the New England Cranberry Sales Company being taken. Some of this fruit was then placed in two new bushel picking boxes, with solid bottoms and slatted sides, and stored until January 19, when it was run through a separator, screened, and then examined again, as before, for size. These two boxes of berries were weighed five times, on the following dates: October 11, October 24, December 18, January 3 and January 10. The experience with this fruit is shown in detail in Tables 10, 11 and 12.

TABLE 10. — *Relative Water Loss of Early Black Cranberries, in Boxes with Solid Bottoms and Slatted Sides, in Different Periods of the Storage Season.*

Box Number.	Weight (Gross) on October 11 (Ounces).	Weight (Gross) on October 24 (Ounces).	Loss in Weight between October 11 and October 24 (Ounces).	Average Daily Loss between October 11 and October 24 (Ounces).	Weight (Gross) on December 18 (Ounces).	Loss in Weight between October 24 and December 18 (Ounces).	Average Daily Loss between October 24 and December 18 (Ounces).	Weight (Gross) on January 3 (Ounces).	Loss in Weight between December 18 and January 3 (Ounces).	Average Daily Loss between December 18 and January 3 (Ounces).	Weight (Gross) on January 10 (Ounces).	Loss in Weight between January 3 and January 10 (Ounces).	Average Daily Loss between January 3 and January 10 (Ounces).
1, ...	737	728	9	.6923	708½	19½	.3545	704½	4	.25	703	1½	.2143
2, ...	733	724	9	.6923	705	19	.3455	701	4	.25	699	2	.2857
Averages, .	735	726	9	.6923	706¾	19¼	.3500	702¾	4	.25	701	1¾	.2500

The table shows that the average daily water loss of these berries was about two and three-fourths times as great during the first period (October 11 to October 24) as it was during the last two periods (December 18 to January 10), while it was intermediate in amount in the second period

(October 24 to December 18). This strongly confirms the results obtained in the water-loss tests with Late Howe berries, showing, in the opinion of the writer, the effect of seasonal variation in temperature on water loss. It should be stated here, however, that no records of the humidity of the storage room were kept at any time in connection with any of the tests discussed in this report.

TABLE 11. — *Total Water Loss of Early Black Cranberries, in Boxes with Solid Bottoms and Slatted Sides, between October 24 and January 10.*

Box Number.	Weight (Gross) on October 24 (Ounces).	Weight (Gross) on January 10 (Ounces).	Weight of Empty Box on January 10 (Ounces).	Net Weight of Berries on October 24 (Ounces).[1]	Net Weight of Berries on January 10 (Ounces).	Loss in Weight between October 24 and January 10 (Ounces).	Percentage of Weight Shrinkage, due to Loss of Water, between October 24 and January 10.
1, ...	728	703	144	584	559	25	4.281
2, ...	724	699	139	585	560	25	4.274
Averages, . .	726	701	141½	584½	559½	25	4.277

As will be seen by a comparison of the figures in Table 8 with those in Table 11, the Late Howe berries averaged to lose approximately the same amount of water between October 24 and January 10 as did the Early Black fruit stored in the same way.

TABLE 12. — *Comparison of Weight Shrinkage (Water Loss) and Quantity Shrinkage.*

Box Number.	Net Weight of Berries on October 11 (Ounces).	Net Weight of Berries on January 10 (Ounces).	Loss in Weight between October 11 and January 10 (Ounces).	Percentage of Weight Shrinkage, due to Loss of Water, between October 11 and January 10.	Average Number of Berries in 7 Cup Samples (Screened) on October 11.	Average Number of Berries in 9 Cup Samples (Screened) on January 19.	Percentage of Quantity Shrinkage as shown by Comparison of Counts of Cup Samples of October 11 and January 19.
1, ...	593	559	34	5.734	109 6/7	115 5/9[2]	5.395
2, ...	594	560	34	5.724	111 2/7	115 5/9[2]	3.788
Averages, . .	593½	559½	34	5.729	110 5/14	115 5/9	4.590

[1] The change in the weight of the boxes themselves was not considered.

[2] As the berries of the two boxes had become mixed in the process of screening, one set of cup samples answered for both.

A comparison of the percentages given in the table shows that the shrinkage in quantity from October 11 to January 19 averaged to be about 20 per cent. less than that in weight from October 11 to January 10. As is indicated by the word "screened," none of the berries in the cup samples showed decay. If the disintegration due to incipient decay was a large factor, as it probably was, in causing the quantity shrinkage, the loss of water in cranberry storage does not appear to cause anything like a corresponding loss in quantity of fruit.

(*d*) *To determine the Period in the Cranberry Storage Season in which the Greatest Development of Decay occurs.* — Only one series of tests was carried out for this purpose, as follows: —

Two lots of Late Howe berries, of 4 bushels each, picked in the same location on October 12, were stored in the same way in the same kind of boxes on October 26. One lot was run through a Hayden separator and screened just before it was stored, while the other was stored as it came from the bog, without any cleaning aside from the removal of such loose vines as could be readily taken out by hand. These eight boxes of fruit were examined by means of cup samples on January 8, 12$\frac{3}{4}$ per cent. of rotten or partly rotten berries being found in the lot that was not cleaned before it was stored, while only 8$\frac{3}{4}$ per cent. was found in the lot that was screened. If the tendency of these berries to decay was doubled by the process of cleaning, as, in the light of the results of tests described elsewhere in this report, seems very probable, it may be properly estimated that, if the cleaned lot of fruit had not been injured at all by the cleaning, its normally developed decay in these tests would not have been over 4$\frac{3}{8}$ per cent. If, then, 4$\frac{3}{8}$ per cent. may be fairly regarded as representing the normal amount of storage decay that developed among these berries between October 26 and January 8, as compared with 12$\frac{3}{4}$ per cent., the total amount of rot found among the berries that were not cleaned previous to storage, it appears that over 8 per cent. of these berries, picked on October 12, were already partly or wholly rotten two weeks later. There was probably some rot among this fruit when it came from the bog, but, if this is neglected, it may be concluded that nearly twice as much rot developed in the period between the 12th and 26th of October as in that between the 26th of October and the 8th of January. It would appear from this that the most rapid development of decay takes place in the very first part of the storage season. Different lots of fruit infected with different diseases, however, probably would vary considerably in this respect.

(*e*) *To determine the Effect of an Admixture of "Vines" on the Development of Decay among Cranberries in Storage.* — No specially planned tests were carried out for this purpose, but the examination of the berries stored in boxes showed that, as a rule, in each stack those boxes which seemed to have the largest admixture of leaves also had the largest percentage of rotten berries. The writer does not consider, however, that the evidence at hand justifies a definite conclusion in regard to this, his

observations in this connection being presented here merely as an indication that the generally accepted opinion among cranberry men, that berries keep better with vines among them, is possibly not correct. Vines without leaves would probably aid in the ventilation of stored berries and so help in retarding the development of rot. There is no evidence, on the other hand, to show that leaves might not have an entirely opposite effect, and, unfortunately, most of the vines that get mixed with the fruit in picking are well supplied with them. Tests to definitely determine this matter in the near future are planned.

(*f*) *To determine whether an Admixture of Decayed Berries usually promotes the Development of Rot in Cranberry Storage.* — The following single series of tests was conducted in this connection: —

Two dozen tin 1-quart cans were filled with Late Howe berries, taken carefully by hand from boxes of fruit that had not been run through a separator, on October 23, and were stored with their covers on tight but not sealed. In twelve of these cans all the berries were apparently entirely sound when stored, while in each of the other twelve, 10 entirely rotten berries were mixed with the good ones. When this fruit was examined on January 4, slightly less decay was found in the latter cans than in the former, there being no evidence to show that contact with the rotten berries had promoted the development of decay at all. Berries infected with different diseases, however, might have shown different results.

(*g*) *To determine the Relationship of the Degree of Ripeness of Cranberries when picked to their Keeping Quality.* — Two bushels of Early Black cranberries, picked on October 23, were placed in storage at once without any cleaning, being at that time very dark colored but apparently in good condition. This fruit was examined on January 10, and was then found to contain a larger percentage of rotten and partly rotten berries than any other lot tested, the other Early Black berries having been picked on different dates between the 10th and 23d of September and having been stored as they came from the bog. The experience with this fruit agrees with the results of similar tests carried out in previous seasons, in showing that there is a stage of ripeness beyond which the keeping quality of Early Black berries greatly deteriorates. It seems safe to say that berries of this variety should, if the winter flowage has been let off early the spring before, all be picked by the 15th of September, and should never under any circumstances be left on a bog later than the 25th of that month.

A lot of Late Howe berries, picked in a previous season on the 13th of November, developed less decay in storage than did any of the other untreated berries tested that year. In this year's tests the berries of this variety which were picked latest kept best. It seems probable, from these results and from other experience, that Late Howe berries, to be their best, should never be picked before the end of the first week in October.

(*h*) *To determine the Extent of the Injury to the Keeping Quality of Cranberries caused in the Process of "Separating."* — Five series of tests were conducted for this purpose, as follows: —

1. Three lots, each consisting of twelve 1-quart cans of Late Howe berries, none of which showed any decay when they were put in the cans, immediately after they had been run through a Hayden separator, on the 27th of October. The first lot was taken carefully by hand from among the berries in the separator barrels, the second lot in the same way from among those in the first separator box (the "good" box), and the third lot from those in the "second" box. When this fruit was taken out of storage on January 4, 21.28 per cent. of the berries in the first lot, 26.39 per cent. of those in the second lot, and 34.5 per cent. of those in the third lot were found to be partly or wholly rotten, the berries from the first separator box thus showing an increase of 24 per cent. and those from the second box an increase of about 62 per cent. in their tendency to rot as compared with that of the berries taken from the separator barrels. Unfortunately, no record was kept as to the part of the barrels (top, middle or bottom) from which the first lot of berries was taken.

2. This series was conducted as a check on the previous one, and was carried out in the same way in every respect, the berries being run through the separator and put in the cans on the 28th of October and being taken out of storage on the 5th of January. In this series 17.06 per cent. of the berries in the first lot were found to be entirely or partly rotten, as compared with 26.23 per cent. in the second lot and 34.27 per cent. in the third. The berries from the first separator box thus showed an increase of about 54 per cent. and those from the second box an increase of about 100 per cent. in their tendency to rot, as compared with those from the separator barrels. In the opinion of the writer the berries of the first lot, in this case, were taken from the top fruit of the separator barrels, though no record in regard to this was kept.

3. Two lots of Early Black fruit were stored in 1-quart cans on the 18th of January, none of the berries showing any rot at the time. The twelve cans of berries in the first lot were not run through a separator, but were taken carefully by hand from four boxes of uncleaned fruit, three cans being taken from the middle portion of each box, one from the top, one from the center and one from the bottom. The second lot, consisting of twenty cans of berries from the same four boxes from which those of the first lot were taken, was taken from separator barrels filled one-third full when this fruit was run through a Hayden machine. When these berries were examined one month later (February 18), an average of 17.14 per cent. of those in the first lot was found to be wholly or partly rotten, as compared with an average of 37.14 per cent. in the second lot, the tendency to rot, among the berries run through the separator, thus appearing to be about 117 per cent. greater than that of those taken directly from the uncleaned fruit. It is doubtful, however, if this figure fully represents the injury done in separating in this case, for the keeping quality of the berries in the first lot was probably poorer at the start than the average of that of the fruit in the four boxes from which the berries of both lots came, as clearly appears from the results of the third series of storage experiments discussed in this report (shown in Table 5).

4. Two lots, each consisting of six 1-quart cans of Late Howe berries, none of which showed any decay, were placed in storage on the 18th of January. The berries of both lots came originally from the same source. Those of the first lot, having been run through a Hayden separator only once, were taken from the first separator box (the "good" box). Those of the second lot, having been run through the separator once, were then taken from the first box and put through the machine a second time and caught in a box held close up to the spout of the separator in place of the separator barrels. This fruit was examined February 18, 12 per cent. of the berries in the first lot being found to be wholly or partly rotten, as compared with 23.44 per cent. of those in the second lot. It thus appears that the second machining of the second lot of berries caused an increase of about 95 per cent. in their tendency to decay.

5. Enough boxes of Late Howe berries from the same source were run through a Hayden separator on January 19 to fill both of the separator barrels. Nine tin 1-quart cans were filled with berries from the top of each of these barrels and placed in storage. Two-thirds of the fruit left in the barrels were then dipped out carefully, and nine more cans were filled with berries from the bottom portion of each barrel and stored for comparison with the other eighteen. None of the berries put into any of these cans showed any rot when they were placed in storage. They were taken out of storage and examined on February 19, the results obtained being shown in detail in the following table: —

TABLE 13. — *Injury to Keeping Quality of Cranberries caused by their Drop in Barrels.*

PART OF SEPARATOR BARREL FROM WHICH THE BERRIES WERE TAKEN.	Barrel.	Number of Cans.	Total Number of Berries in the Cans.	Number of Rotten and Partly Rotten Berries found on February 19.	Percentage of Berries found to be Rotten or Partly Rotten on February 19.	Averages of Percentages of Rotten and Partly Rotten Berries.
Top, ...	1	9	4,108	350	8.52	8.81
	2	9	4,351	396	9.10	
Bottom, ...	1	9	4,200	565	13.45	13.78
	2	9	4,128	583	14.12	

As will be seen by the above table, the rot development among the berries from the bottom part of the separator barrels, as compared with that in the fruit from the top part, showed that the injury due to the drop in the barrel had increased the tendency to rot about 56 per cent.

(*i*) *To determine the General Rate of Temperature Changes among Barreled and Crated Cranberries.* — The two following tests were conducted in this connection: —

1. Some Late Howe berries were heated in picking boxes in a warm room and packed in a barrel as if for shipment. A dough thermometer was inserted in a hole bored in the center of each head of the barrel, its bulb reaching in 9 inches among the berries; and another was placed in a hole in the bilge, its bulb reaching to the very center of the fruit. The temperature of the barreled berries at 5.15 P.M., February 15, was shown by these thermometers to range from 65 to 67 degrees Fahr. The barrel, with the thermometers in place, was then put at once in the basement of the station screen-house, the temperature of the basement at the time, as shown by a Green minimum thermometer placed near the barrel, being 34 degrees Fahr. During the following twenty-four hours, the basement temperature ranged between 31 and 34 degrees. The thermometers in the barrel, at 5.15 P.M., February 16, showed an average temperature of 51 degrees among the berries, their temperature having fallen about 15 degrees in the twenty-four hours. Between 5.15 P.M., February 16, and 5.15 P.M., February 17, the basement temperature ranged between 33 and 35½ degrees, and at the latter time the temperature of the barreled berries was found to average 42 degrees, it having dropped 9 degrees during the second period of twenty-four hours. Between 5.15 P.M., February 17, and 11.15 A.M., February 18, the basement temperature ranged from 32 to 36 degrees, and at the latter time the average temperature of the barreled berries was 38¾ degrees, it having dropped only 3¼ degrees in the last eighteen hours (or at the rate of 4⅓ degrees in twenty-four hours). At 5.15 P.M., February 18, the temperature of both the basement and the berries was 38 degrees. As will be seen, it took practically three days for the temperature of this barrel of berries to come down to that of the basement, there being an initial difference of about 32 degrees between them. Presumably, a considerably longer period would have been required to equalize these temperatures if that of the basement had not risen toward the end of the test.

When the length of time required to bring the temperature of this single barrel down to that of the basement is considered, it seems that the temperature changes of carload lots of barreled berries must be very slow.

2. A shipping crate of Late Howe cranberries was handled in the same way as the barrel of fruit in the previous test, except that a glass chemical thermometer, instead of a dough thermometer, was inserted into each compartment of the covered crate in such a way as to take the temperature of the berries at its very center. The temperatures were taken when those of the barrel test were. The average initial temperature of the berries in this crate was about 69 degrees Fahr. and it took it about forty hours to come down to that of the basement.

Practical Conclusions based on the Results of the Storage Tests.

Much of the experience gained in these experiments was of such a nature that it cannot be given in detail in this report, but it is considered

freely, in connection with the results of the tests that have been described, in formulating the conclusions that follow: —

1. While ventilation is a very important factor in retarding the development of rot, it is doubtful if, all things considered, it would pay cranberry growers to go to any considerable expense in making special arrangements to provide for it in connection with the storage of their fruit previous to shipment, except, perhaps, in storage-house construction. As a rule, berries of poor keeping quality are shipped as soon as possible after they are picked, and it is only with such fruit that the maximum benefit to be gained by superior arrangements for ventilation would be realized. Some precautions, however, which do not call for much expenditure of either time or money, can apparently be taken with much advantage. Among these, the thorough airing of the storage house on cool, dry days, and the allowance of as much space in the storage of the fruit as circumstances permit, may probably be properly mentioned.

2. Special attention to the keeping down of temperatures appears to promise fully as great advantages, as far as storage previous to shipment is concerned, as can be obtained from special arrangements for ventilation.

3. Storage house construction, in its relations to temperature and humidity, is urgently calling for careful scientific study.

4. Methods of preparing the fruit for shipment are not receiving the attention they deserve. The following suggestions in this connection are here advanced for consideration: —

(*a*) The injury to the keeping quality of cranberries, caused in the process of their preparation for shipment by the methods at present generally followed, is enormous, and would be endured by hardly any other kind of fruit. Special harm appears to be done by the bouncing of the berries in the separators and by their drop into the barrels in separating and screening. It ought not to be difficult to devise simple means for greatly reducing this barrel injury, and separators of the general type of the White machine promise, in the opinion of the writer, to damage the fruit much less than those which employ the bouncing principle. Unfortunately, separators that make use of the snapping principle (White machine) are likely to be comparatively expensive, and, at the same time, have a relatively small capacity; these disadvantages, under present marketing conditions, making the use of such machines almost prohibitive, except with large growers. If community packing houses were established, however, such machines could probably be used extensively with no little advantage.

(*b*) No berries that are to be branded should ever be run more than once through a separator employing the bouncing principle.

(*c*) At present, cranberries are usually shipped in barrels, and the writer is informed that most dealers prefer to handle this fruit in such containers. If the maintenance of the fruit in good condition is a matter of first importance, however, great disadvantages are obviously connected with the use of the barrel. The pressure of the top fruit on that at the

bottom in so large a package must do injury, and the squeezing which the berries undergo in the process of packing and the almost complete lack of ventilation in fruit packed so tightly in such quantity are certainly highly detrimental. In this connection it is here suggested that a thorough testing of the possibilities connected with the use of ventilated crates in shipping this fruit might produce valuable results. The use of such crates would not only help in preserving the condition of the berries while in transit, but would also insure, to a certain extent, a proper storage for them while they were in the hands of the retailer, ventilation being, as has already been shown, one of the more important factors in good cranberry storage. A desirable trade in cranberries shipped in crated strawberry baskets might perhaps be developed.[1]

(*d*) It may be found advisable to ship crated cranberries in the uncleaned condition (before they have been run through a separator) to the trade in the more distant parts of the country, for the fruit would be in a far more acceptable condition in such sections if it were prepared for market at central distributing points in the territory where it was to be consumed.[2]

(*e*) The slow rate of temperature changes in the barreled fruit suggests that berries might be moderately cooled, both before storage and before shipment, to advantage. The writer knows of no tests conducted in this connection, however.

Resanding.

The season's experience with the five sanding plots, results with which have been discussed in previous annual reports, are shown in detail in Table 14. The areas used as checks on these plots are measured off anew each year on the general bog surface immediately adjoining the plots, and, for this reason, as is shown in Table 15, they vary considerably in size from year to year. All the Early Black plots and their checks were picked this season on September 18, and the Late Howe plot with its checks on October 12, all the picking being done with scoops.

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[1] This suggestion is contributed by certain growers connected with the J. J. Beaton Growers Agency of Wareham, Mass.

[2] Suggested by Mr. J. J. Beaton, Wareham, Mass.

TABLE 14. — *Sanding Plots in 1915. — Effect of Resanding on Quantity and Keeping Quality of Cranberries.*

PLOTS AND CHECKS.	Variety.	Area of Plot (Square Rods).	When resanded.	Quantity of Fruit picked (Bushels).	Quantity of Fruit per Square Rod (Bushels).	Number of Bushels in Storage Tests.	Date examined to determine Percentage of Rotten Berries.	Method of Examination.	Percentage of Berries found Partly or Wholly Rotten in Storage Test.
V, ...	Early Black.	9	Not since November, 1909.	12.875	1.43	4	Jan. 15	Nine-sample.	29.32
V (check 1), ...	Early Black.	9	Spring of 1912 and fall of 1914.	7.250	.81	4	Jan. 15	Nine-sample.	37.04
V (check 2), ...	Early Black.	9	Spring of 1912 and fall of 1914.	6.857	.76	4	Jan. 15	Nine-sample.	22.19
O, ...	Early Black.	9	Not since November, 1909.	8.125	.90	4	Jan. 15	Nine-sample.	19.95
O (check 1), ...	Early Black.	9	Fall of 1911 and fall of 1914.	8.500	.94	4	Jan. 14	Nine-sample.	22.58
O (check 2), ...	Early Black.	9	Fall of 1911 and fall of 1914.	4.670	.52	4	Jan. 15	Nine-sample.	25.01
N, ...	Early Black.	9	Yearly in the fall, 1911 to 1914, inclusive.	6.000	.67	4	Jan. 6	Five-sample.	19.21
N (check 1), ...	Early Black.	9	Fall of 1911 and fall of 1914.	6.500	.72	4	Jan. 6	Five-sample.	17.70
N (check 2), ...	Early Black.	18	Fall of 1911 and fall of 1914.	8.916	.50	-	-	- -	-
R, ...	Early Black.	9	Yearly in the fall, 1911 to 1914, inclusive.	8.110	.90	4	Jan. 8	Nine-sample.	20.86
R (check), ...	Early Black.	6	Fall of 1911 and fall of 1914.	3.900	.65	4	Jan. 8	Nine-sample.	17.25
T, ...	Late Howe.	9	Yearly in the fall, 1911 to 1914, inclusive.	11.500	1.28	4	Jan. 6	Five-sample.	13.53
T (check 1), ...	Late Howe.	9	Fall of 1911 and fall of 1914.	9.330	1.03	4	Jan. 6	Five-sample.	13.94
T (check 2), ...	Late Howe.	6	Fall of 1911 and fall of 1914.	6.330	1.06	4	Jan. 6	Five-sample.	13.37

Summary of Table 14.

	Area of Plots (Square Rods).	When resanded.	Quantity of Fruit picked (Bushels).	Quantity of Fruit per Square Rod (Bushels).	Number of Bushels in Storage Tests.	Date examined to determine Percentage of Rotten Berries.	Percentage of Berries found Partly or Wholly Rotten in Storage Tests.
Plots O and V,	18	Not since November, 1909.	21.000	1.17	8	Jan. 15	24.635
Checks O and V,	36	Twice since 1909.	27.277	.76	16	Jan. 14, 15	26.705
Plots N, R and T,	27	Yearly in the fall, 1911 to 1914, inclusive.	25.610	.95	12	Jan. 6, 8	17.870
Checks N, R and T,	48	Twice since 1909.	34.976	.73	16	Jan. 6, 8	15.565

The amounts of fruit gathered from these plots and their checks each year, from 1912 to 1915, inclusive, and their averages, are given in the following table: —

TABLE 15. — *Effect of Resanding on Fruit Production.*

Plots and Checks.	Variety.	Area (Square Rods).	When resanded.	Quantities of Fruit per Square Rod (Bushels).				
				1912.	1913.	1914.	1915.	Average for the Four Years.
V,	Early Black.	9	Not since 1909.	.444	2.019	1.111	1.430	1.250
V (checks),	Early Black.	13½ to 21[1]	Spring of 1912 and fall of 1914.	.310	2.259	.856	.785	1.052
O,	Early Black.	9	Not since 1909.	.278	1.389	.889	.900	.864
O (checks),	Early Black.	18 to 24	Fall of 1911 and fall of 1914.	.258	1.917	.674	.730	.895
N,	Early Black.	9	Yearly in the fall, 1911 to 1914, inclusive.	Not started.	2.222	.800	.670	1.231
N (checks),	Early Black.	12 to 27	Fall of 1911 and fall of 1914.	-	2.358	.687	.610	1.218
R,	Early Black.	9	Yearly in the fall, 1911 to 1914, inclusive.	Not started.	1.889	1.111	.900	1.300
R (checks),	Early Black.	6 to 12	Fall of 1911 and fall of 1914.	-	1.944	1.125	.650	1.240
T,	Late Howe.	9	Yearly in the fall, 1911 to 1914, inclusive.	Not started.	2.278	1.259	1.280	1.606
T (checks),	Late Howe.	15 to 24	Fall of 1911 and fall of 1914.	-	2.424	1.213	1.045	1.561

[1] There were two or three checks on each of these plots each year, except that plot R was given only one in 1915. These figures show the range in the total area of the checks added together in the various years. Whenever two checks were used they were laid out on opposite sides of the plot.

As will be seen by the figures given in Table 15, these plots have shown no very definite effect on the quantity of fruit produced, resulting from resanding or the lack thereof. In the opinion of the writer the advantages gained by resanding are of such a general nature — a certain amount of frost protection and help in the control of the tip worm and girdler being the most evident — that they are not definitely determinable by means of plot experiments.

Fertilizers.

The experiments with the fertilizer plots on the station bog, spoken of in previous reports, were continued. Table 16 presents a résumé of the experience with these plots from 1911, the year in which they were started, up to the present time. Unfortunately, no storage tests were conducted in 1911.

TABLE 16. — *Effect of Fertilizers on Quantity and Keeping Quality of Cranberries.*

Plot.	Fertilizer used.	Quantities of Fruit produced, 1911 to 1915, inclusive (Bushels).						Percentages of Loss in Storage Tests, 1912 to 1915, inclusive.				
		1911.	1912.	1913.	1914.	1915.	Total for the Five Years.	1912.	1913.	1914.	1915.	Average of the Four Years.
1,	0	10.0	1.875	15.833	9.000	5.833	42.542	34.38	37.26	27.45	26.26	31.34
2,	N	12.0	3.250	16.500	9.500	6.167	47.417	29.69	36.77	31.37	29.69	31.88
3,	P	11.0	2.000	15.667	8.800	5.500	42.967	27.81	33.00	20.59	22.20	25.90
4,	K	11.0	1.750	17.000	8.000	5.500	43.250	29.69	34.00	24.51	25.85	28.51
5,	0	13.0	1.750	19.333	6.500	7.600	48.183	29.70	39.22	26.96	32.13	32.00
6,	NP	16.0	3.143	19.167	6.667	7.750	52.727	23.44	38.24	34.00	26.53	30.55
7,	NK	14.5	3.875	18.833	7.667	8.000	52.875	21.88	30.88	31.37	28.09	28.05
8,	PK	14.5	2.750	17.750	8.667	8.167	51.834	18.75	35.29	23.53	25.71	25.82
9,	0	14.0	2.333	17.667	6.500	4.917	45.417	16.80	27.45	29.41	22.12	23.94
10,	NPK	14.0	4.000	20.000	8.667	7.333	54.000	18.75	35.30	33.00	22.51	27.39
11,	NPKL	16.0	3.500	17.750	8.167	6.333	51.750	16.67	38.24	37.25	37.27	32.36
12,	NPKcl	15.0	3.400	20.333	7.750	7.200	53.683	15.63	36.76	28.43	28.32	27.28
13,	0	12.0	2.500	19.167	7.667	5.667	47.000	18.75	33.33	22.53	15.45	22.51
14,	$N_{1\frac{1}{2}}PK$	12.0	4.833	17.750	10.000	6.875	51.458	16.67	33.00	24.51	27.10	25.32
15,	N_2PK	10.0	6.111	9.833	10.417	5.833	42.194	25.00	44.61	26.96	27.33	30.97
16,	$NKP_{1\frac{1}{2}}$	10.0	5.667	18.000	9.000	7.000	49.667	18.75	36.27	27.45	21.64	26.03
17,	0	10.5	3.167	20.333	9.667	7.000	50.667	22.66	33.33	23.04	18.33	24.34
18,	NKP_2	10.0	5.500	18.000	10.000	6.200	49.700	16.67	35.78	30.39	23.42	26.56
19,	$NPK_{1\frac{1}{2}}$	10.0	4.000	19.125	9.000	6.833	48.958	21.88	35.30	25.49	21.40	26.02
20,	NPK_2	12.5	4.200	20.000	6.833	7.333	50.867	25.00	43.63	31.37	29.24	32.31
21,	0	11.5	3.000	22.125	10.333	6.067	53.025	31.25	41.18	32.50	25.90	32.71
22,	0	11.5	3.125	–	10.800	–	–	28.13	–	–	–	–
23,	0	14.5	2.000	20.000	6.333	–	–	17.50	38.15	22.22	–	–

The area of each of these plots is 8 square rods.

Plots 1 5, 9, 13 17, 21 22 and 23 are all untreated check plots. The meanings of the fertilizer symbols used in the table are as follows: —

0 = Nothing.
N = 100 pounds nitrate of soda per acre.
P = 400 pounds acid phosphate per acre.
K = 200 pounds high-grade sulfate of potash per acre.
L = 1 ton of lime (slaked) per acre.
Kcl = 200 pounds muriate of potash per acre.
$N_{1\frac{1}{2}}$ = 150 pounds nitrate of soda per acre.
N_2 = 200 pounds nitrate of soda per acre.
$P_{1\frac{1}{2}}$ = 600 pounds acid phosphate per acre.
P_2 = 800 pounds acid phosphate per acre.

In combination they mean, for example, as follows: N_2PK = 200 pounds of nitrate of soda + 400 pounds of acid phosphate + 200 pounds of high-grade sulfate of potash per acre.

The fertilizers were applied in the different years on dates as follows: 1911, middle of July; 1912, June 25 and 26; 1913, July 15; 1914, June 17 and 18 (except plot 12 and the lime on plot 11, July 17); 1915, June 26 and 28. The plots were all picked with scoops each year, on dates as follows: 1911, September 13 and 15; 1912, September 11 and 12; 1913, September 15 and 16; 1914, September 16 and 17; 1915, September 14 and 16.

The berries were run through a separator before they were placed in storage tests in 1912 and 1914. They were stored without separating in 1913 and 1915, — in the latter year as soon as they were picked. The percentages of loss in storage were obtained from measurements of the quantities of fruit at the beginning of the tests and after the screening was done at their close in 1912, 1913 and 1914. In 1915 they were obtained by averaging the results of the examinations of cup samples, taken from January 3 to 7, inclusive, the results of the sampling being shown in some detail in Table 3.

The figures in the table seem to show a moderate average increase in the quantity of fruit obtained during the five-year period from the fertilized areas as compared with that from the checks. The figures given for plot 15 are misleading, as half of that plot was used in spraying tests with Bordeaux mixture, there being a considerable reduction in its quantity of fruit some years as a consequence.

The average percentages of loss in the storage tests seem to indicate that the nitrate of soda impaired the keeping quality of the fruit somewhat, while no effect in this respect connected with the use of acid phosphate and sulfate of potash is apparent. It will be noted that the berries from the plot treated with lime did not keep at all well in 1914 and 1915 as compared with those from the other plots, though in the 1912 tests they showed about as little decay as any. It should be stated in this connection that a marked scattering of dead and dying vines developed on all parts of this plot in the late summer and fall of 1915, no other con-

siderable area on the entire bog being thus affected. The vines showing this condition appeared entirely like those of the same variety (Early Black) on about ten acres of a bog a few miles away, the other varieties of which (Late Howe and Matthew) showed no such trouble. The Early Black berries picked on this other bog this season showed poor keeping quality both in storage and shipment. It perhaps may be inferred from this that lime favors the development of some disease that is peculiar to the Early Black variety.

The experiments with fertilizers to determine the possibility of stimulating and increasing the "setting" of cranberry blossoms, discussed in the last annual report of the substation (page 102), were continued and extended, one Early Black and one Late Howe plot (each of eight square rods) being treated in addition to the two areas used last year. On the station bog the blossoming period of the Early Black variety extended from July 1 to July 20, and that of the Late Howe from July 9 to July 26. The fertilizer was applied to the two Early Black plots on July 7, and was washed in by a good rain the following day. The Late Howe plots were treated on July 14, but no rain of any consequence followed the application until the 19th. The fertilizer was used on all these plots at the following rate per acre: 160 pounds of nitrate of soda + 400 pounds of acid phosphate + 200 pounds of high-grade sulfate of potash. The Early Black plots and their checks were picked on September 17 and 18, and the Late Howe on October 14, no very distinct advantage in quantity of fruit, on the whole, being shown by the fertilized areas. The berries from three of these plots were put in storage tests, and all showed an impaired keeping quality in comparison with the fruit from the checks.

Insects.

The black-head fire-worm caused about its normal amount of injury during the season. The loss caused by the fruit worm was considerably more than in either 1913 or 1914, but not as great as in some years. The false army worm (*Calocampa nupera* Lintner) has not been generally injurious for several years and was not much in evidence in 1915. The army worm (*Heliophila unipuncta* Haworth), which caused so much apprehension on account of its great abundance in 1914, dropped out of sight, as did also the forest tent-caterpillar (*Malacosoma disstria* Hübner) and the apple-tree tent-caterpillar (*Malacosoma americana* F.), both of which had been tremendously abundant in the cranberry region, as elsewhere, for several previous seasons.

A spanworm commonly seen on cranberry bogs in July, known to science as *Abbotana clemataria* Sm. and Abb.,[1] was reared successfully, the moths emerging between the 20th and 27th of May from pupæ formed between the 9th and 25th of July, 1914. One of the reared moths laid a batch of 432 eggs about May 30. The eggs were green when first deposited, but during the period of incubation they changed first to red, then to

[1] Identified by Mr. August Busck of the Bureau of Entomology, United States Department of Agriculture.

black, taking on the latter color only two or three days before they hatched. The young caterpillars emerged on June 14 and were mostly black in color. These worms full-grown were about 2½ inches long and of a fairly uniform chocolate-gray color. They went down to a maximum depth of 2 inches in the sand of the breeding cans to pupate. The pupæ were from 18 to 23 millimeters long and from 6 to 7 millimeters broad across the tips of the wing cases. Their general color was light chocolate-brown, with an irregular sprinkling of fine black spots, the spiracles and their immediate surroundings appearing as very noticeable black spots along their sides; but the wing cases were uniform light brown.

The adult moth measures, with wings spread, about 2 inches from wing tip to wing tip, and is of a light gray color moderately variegated with light brown, appearing as though it were lightly sprinkled over with pepper, with a straight white line running across the hind part of each fore wing, and a noticeable, though small, black spot in front of the middle of each wing. Though commonly seen on the bogs, the caterpillars of this insect have never been found by the writer in sufficient numbers to do any considerable injury. This is the fifth important species of cranberry-attacking spanworm that has thus far been reared, the other four being: *Cymatophora sulphurea* (Packard),[1] the green spanworm commonly found late in May eating holes in the winter buds at the tips of the uprights; *Epelis truncataria* var. *faxonii* Minot, discussed at length in the last two annual reports of the substation; the "chain-dotted geometer" (*Cingilia catenaria* Cram.), a bright yellow worm measuring about 1½ inches in length when full grown, commonly seen on cranberry bogs in small numbers in late July and early August; and the "cranberry spanworm" (*Cleora pampinaria* Gn.), fully discussed by Dr. John B. Smith in Farmers' Bulletin No. 178 of the United States Department of Agriculture. The writer, in eight seasons of cranberry investigation, has never found a caterpillar of the last-named species on any bog, and Prof. H. B. Scammell, after three years' work in New Jersey, has yet to find it there.

An Ichneumonid parasite, *Amblyteles putus* Cress.,[2] was reared from *Cymatophora sulphurea* in small numbers.

What appears to be an infestation by the "cranberry rootworm" (*Rhabdopterus picipes* (Oliv.)) was discovered in October on a bog in Wareham, some two acres showing more or less injury. This insect has not, heretofore, been known to be injurious on any Massachusetts bog, but it is an old and rather serious offender in New Jersey. No beetles have yet been reared in connection with the infestation found in Wareham, but specimens of the grubs and injured vines were sent to Professor Scammell, the entomologist investigating cranberry insects in New Jersey for the Bureau of Entomology of the United States Department of Agriculture, for comparison, and he replied concerning them: "Have just compared your larvæ with some alcoholics of mine and must say that I

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[1] See Entomological News, Vol. XVIII, p. 17, 1907.

[2] Determined by Dr. J. F. Martin, who recently finished his postgraduate course at the Massachusetts Agricultural College, specializing with the Ichneumonidæ.

cannot detect any difference between them. The injury to the roots seems to be identical with that caused by *R. picipes* here, and I therefore offer the opinion that your specimens are *Rhabdopterus picipes* Oliv."

A bog injured by this insect has a general appearance similar to that of one damaged by the cranberry girdler (*Crambus hortuellus* Hbn.), the patches of dead vines being very irregular in form and distribution. Roots injured by the girdler, however, have the wood as well as the bark eaten considerably, frequently being entirely cut off, while the large and secondary roots worked on by the rootworm show practically no injury to the wood, only the bark being eaten away. The girdler feeds on the surface, concealed in fallen leaves or other trash which lies over the sand, and prefers the runners and crowns of the plants, while the rootworm works in the soil and feeds very largely on the fibrous roots which, though they form a dense mat an inch or more in thickness, are frequently almost completely devoured.

The bog area which has this newly discovered Massachusetts infestation is completely flowed every winter to a constant depth of about 9 inches. It has a peat "bottom" with first-class drainage during the growing season. It has been resanded every other year for the past ten years. When it was examined on December 8, most of the grubs were found just below the inch and one-half thickness of frozen surface sand, but they ranged to a maximum depth of 8 inches.

On September 16 the writer examined a bog in South Carver on which small beetles in great numbers had been for some time devouring the foliage. The infested bog was circular in form and had a total area of about five acres. One and one-half acres in the very middle part had been turned brown by the insect in a way to suggest, to one viewing it from some distance, a severe fire-worm attack. The beetles were mating very freely at the time and were also feeding on the cranberry foliage voraciously, the backs of the leaves receiving most of their attention, though the front side was also eaten considerably. A quantity of these insects was collected and preserved, and they have been identified [1] as belonging to the species known to science as *Cryptocephalus incertus* Oliv. The beetles are from about 2 millimeters to about 3 millimeters (from less than three thirty-seconds to about one-eighth inch) in length, the smallest specimens being males while the larger ones are females. As a rule, they are seal brown in color, though some of the females are almost black. Both sexes have rather conspicuous, though poorly defined, white longitudinal stripes on the wing covers.

The manager of the infested bog had noticed a considerable injury to the vines as early as the 20th of August, though he did not discover the beetles until a few days before the writer's visit. This fact, taken in connection with the very general mating observed, leads to the suspicion that much of the injury seen by the writer had been caused by the larvæ of the insect. The infested bog is eighteen years old, has been completely

[1] By Mr. E. A. Schwarz of the Bureau of Entomology of the United States Department of Agriculture.

winter flowed every year for several years, this flowage having been let off between March 15 and April 1 in both 1914 and 1915, and has been resanded every other year for the past twelve years. It was reflowed in June as usual. Early Black and Late Howe vines were injured somewhat, but the variety most affected was the Chipman.

As a matter of passing interest, it was noticed that the caterpillars of the apple sphinx moth (*Sphinx gordius* Cramer), usually found on the bogs in considerable abundance by the pickers, seemed to be almost entirely absent this fall, not a single one being found on the station bog where they were in evidence in large numbers in the fall of 1914.

The writer has observed the oyster-shell scale (*Lepidosaphes ulmi* L.) in more or less abundance on cranberry vines on dry bogs for several years, a rather seriously injurious infestation being occasionally found. This insect apparently never becomes very abundant on bogs that are winter flowed.

The Gypsy Moth (*Porthetria dispar* L.).

There are apparently four distinct ways in which a bog may become infested with this pest, as follows: —

1. *By the Hatching of Eggs deposited on the Bog the Previous Year.* — This is probably the principal source of trouble under present conditions. Egg masses on a bog in Carver which, having become completely flowed by the accumulation of rains to a depth of 10 inches by the 1st of February, had the water all pumped off by the 11th of April were observed by the owner to hatch fairly well afterward.

The writer collected a quantity of egg masses, all from the same general locality, and separated them into three approximately equal batches. One batch was placed in a can in the basement of the station screen-house for the winter as a check. The other two were submerged in 3 feet of water in a pond on January 14. One of these lots was taken out of the pond on April 1 and the other on May 20. Practically all the eggs kept in the screen-house hatched normally, while only about half of those taken from the water on April 1 and none of those taken out on May 20 hatched. These experiments indicate that late holding of the winter flowage (until May 20), when practicable, may be relied upon to wipe out an old infestation.

If, for any reason, late holding of the winter water is not desirable, reflowing will undoubtedly prove a satisfactory method of control where water supplies are abundant, if applied about May 20 and again about June 5, care being taken to kill by burning or by spraying with kerosene those caterpillars that succeed in floating ashore alive. If spraying must be resorted to, it should be done while the worms are yet in their early stages. Most of the eggs usually hatch between May 5 and May 18. To be most effective, the spraying should probably be done about May 15, and should, if the infestation is very serious, be repeated a week later to kill the worms that hatch afterwards. It is the writer's experience that

caterpillars of the false army worm may be easily found in their very first stages by sweeping the vines hard with an ordinary insect collector's net, and the seriousness of an infestation determined by making counts of the worms thus captured. As the false army worm clings to the vines with much the same tenacity as the gypsy, it seems probable that an infestation by this insect may be estimated in the same way, and the advisability of spraying be thus ascertained. If an average of not more than 5 or 6 small false army worms are captured with 50 sweeps of the net, the infestation is usually not serious enough to call for spraying, while 15 or 20 worms caught with the same number of sweeps shows that spraying is pretty certainly necessary. It is presumed that similar counts will apply with the gypsy.

2. *By Wind Drift of the Worms in their Early Stages.* — It has been abundantly proved that the first instar worms of this insect are frequently carried several miles by strong winds, the long hairs with which their bodies are clothed causing them to be easily spread in this way. The period of their wind dispersal in large numbers usually extends from about May 14 to June 1. If, therefore, the winter flowage is held until about June 1, infestation by wind drift will be prevented. With present methods of bog management, however, it usually is not best to hold the winter water so late. Reflowing or spraying, as above indicated, will, therefore, have to be depended upon in most cases. Probably the June flooding commonly practiced for destroying the black-head fire-worm will be found satisfactorily effective in this connection.

3. *By Worms falling on Bog Margins from Overhanging Trees.* — The uplands around most bogs are now entirely cleared of trees and brush for some distance back from the bog margin. The chances of gypsy infestation in this way are, therefore, in most cases, very slight. To say, in this connection, that all bog margins should be entirely cleared of arborescent growths is superfluous.

4. *By the Caterpillars crawling across Marginal Ditches after they become Large.* — A serious infestation can come about in this way only when the surrounding upland is very heavily infested. It can probably be prevented by keeping the marginal ditch well cleaned out and partly filled with water. As the caterpillars are enabled by their hairs to float a long time before drowning, it may be necessary to cover the ditch water with a film of oil. Fuel oil would be cheap and probably effective for this purpose.

The Cranberry Tip Worm (*Cecidomyia oxycoccana* Johnson).

In July a large number of bogs were examined to determine the proportions of tips injured by the last brood of maggots, this being regarded as the best means of ascertaining the relative amounts of infestation. Table 17 shows the results of these examinations on fourteen different bogs, as compared with the findings of the 1914 investigation.

TABLE 17. — *Amount of Tip Worm Injury in 1914 and 1915. — Effect of Resanding.*

Bog.	Location of Bog.	Bog Dry or Winter Flowed.	Date of 1914 Examination.	Number of Tips examined in 1914.	Number of Tips found Injured in 1914.	Percentage of Injured Tips in 1914.	Date of Removal of Winter Flowage in 1915.	Bog sanded between September, 1914, and May, 1915, or not.	Date of 1915 Examination.	Number of Tips examined in 1915.	Number of Tips found Injured in 1915.	Percentage of Tips injured in 1915.
1,	East Wareham.	Winter flowed.	July 15	438	192	43.84	June 5	Sanded.	July 22	469	13	2.77
2,	East Wareham.	Winter flowed.	July 7	259	177	68.34	May 20	Sanded.	July 15	485	22	4.54
3,	East Wareham.	Dry.	July 7	119	29	24.37	-	Sanded.	July 22	462	64	13.85
4,	East Wareham.	Winter flowed.	July 13	174	22	12.64	May 11	Sanded.	July 23	371	18	4.85
5,[1]	East Wareham.	Winter flowed.	July 10	169	43	25.44	May 21	Sanded.	July 23	378	36	9.52
								Not sanded.	July 23	215	85	39.53
6,	East Wareham.	Winter flowed.	July 14	321	29	9.03	April 25	Not sanded.	July 24	245	67	27.34
7,	East Wareham.	Winter flowed.	July 14	468	51	10.90	April 25	Not sanded.	July 27	558	167	29.93
8,	East Wareham.	Winter flowed.	July 15	135	89	65.93	-	Not sanded.	July 26	638	43	6.74
9,	Carver.	Winter flowed.	July 13	305	209	68.52	-	Not sanded.	July 29	476	329	69.10
10,	East Wareham.	Winter flowed.	July 15	451	160	35.48	April 25	Not sanded.	July 25	463	157	33.91
11,	East Wareham.	Dry.	July 11	122	9	7.38	-	Not sanded.	July 23	259	87	33.59
12,	East Wareham.	Dry.	July 11	111	45	40.54	-	Not sanded.	July 23	311	156	50.16
13,	East Wareham.	Dry.	July 10	145	7	4.83	-	Not sanded.	July 22	362	53	14.64
14,	East Wareham.	Dry.	July 13	163	32	19.63	-	Not sanded.	July 23	208	80	38.46

[1] As part of this bog was sanded while part was not, two separate examinations were necessary in 1915 in place of the one in 1914, which covered both parts. For each of the examinations, results of which are given in the table above, uprights were collected from many different well-scattered locations on the bog. They may, therefore, be considered to have represented the condition of the bog with reasonable accuracy in each case.

A comparison of the figures given in the table shows that there was not a single bog, a record of the 1914 examination of which was kept, that, after being resanded, did not show a tremendous drop in the amount of tip worm infestation. On the other hand, practically only one bog that was not resanded between September, 1914, and May, 1915, failed this year to have an infestation equal to or greater than that of 1914. The single exception (No. 8 in the table) was so heavily frosted late in May that its prospective crop was entirely destroyed and most of its tips killed back. In the opinion of the writer its exceptional condition as regards tip worm infestation was an effect of the frost injury, most of the maggots of an early brood perhaps having been starved to death by the drying up of the tips killed by the frost, this conclusion concerning the effect of frost being in line with those advanced in last year's report of the substation (page 106).

The examination this season of many other bogs besides those listed in the table produced abundant corroborative evidence of the marked effect of resanding on the subsequent amount of infestation by this insect.

In December, uprights from many locations on four different bogs were examined to determine the amount of recovery from injury done by this insect as indicated by the development of buds large enough to promise the production of blossoms therefrom the following season. The results of these examinations are shown in Table 18. The buds in the axils of the leaves, as well as those at the tips of the uprights, were included in making the counts.

TABLE 18. — *Winter Bud Formation subsequent to Tip Worm Injury.*

Bog.	Number of Tips examined.	Number found showing Tip Worm Injury.	Number showing Injury with Blossom Buds.	Percentage of Tips showing Injury with Blossom Buds.	Number not showing Injury with Blossom Buds.	Percentage of Tips not showing Injury with Blossom Buds.
1, ...	388	147	37	25.17	126	52.28
2, ...	760	142	26	18.31	334	54.05
3, ...	350	109	13	11.93	135	56.02
4, ...	228	38	19	50.00	169	88.95

It will be seen from the table that, while a much larger percentage of uninjured tips developed buds, there was, nevertheless, a sufficient recovery among those that were injured to cause a considerable bud production. In view of this and of the fact that the effect of light or heavy cropping is carried over in the vines from one season to another, it is very difficult to say, with any degree of accuracy, how great the loss caused by this insect one year with another really is.

The Black-head Fire-worm[1] (*Rhopobota vacciniana* (Pack.)).

Arsenical sprays, well sweetened with saccharin, were tried against this insect, but no advantage of any consequence resulting from the sweetening was detected.

The writer dislikes the idea of spraying for this pest. At best, it is an expensive and injurious method of treatment. The general conditions of the cranberry industry are making the use of less costly means of control than spraying increasingly imperative for this insect as well as for the other common pests and diseases. The possibilities in this connection are made more apparent in the discussion of bog management included in this report.

In last year's report (page 107), the writer suggested the possibility of treating this insect satisfactorily by holding the winter flowage late enough to kill its eggs, as often as an infestation developed sufficiently to do serious damage, sacrificing the crop in the years of such late holding. He has had the opportunity to observe the results of such late holding to some extent this season. A New Jersey bog appeared to be satisfactorily cleared of the pest by holding the water until the middle of June, and a heavy infestation on a bog in Wareham was very greatly reduced by the holding of a partial flowage until the 1st of July. In the latter case the results, under the conditions, were so satisfactory that it seemed certain that the bog would have been cleared entirely had all the vines been completely submerged. In neither case did the vines appear to be much injured by the water. Those on the Wareham bog bloomed considerably and came to the end of the season well budded and otherwise in good condition, even producing a little fruit.

The Cranberry Fruit Worm (*Mineola vaccinii* (Riley)).

Two netting sacks, each containing 160 cocoons (with worms) of this insect, were submerged in a pond in 3 feet of water on January 15. One of these sacks was taken from the water on March 31, and the cocoons were opened on the same day and their contents examined, 40 per cent. of the worms being found alive, almost a quarter of them being quite active. The other sack was taken from the water on May 20, and the contents of its cocoons were examined on the same day, not a single live worm being found, most of them being more or less decomposed. The results of these experiments are entirely in line with the common experience of cranberry growers, which has for years indicated that the fruit worm could not endure a prolongation of winter submergence far

[1] The American Association of Economic Entomologists, at its last annual meeting (December, 1915), voted to adopt the terms "black-head fire-worm" and "yellow-head fire-worm" as common names for this insect and *Peronea minuta* (Rob.), respectively, in place of the names "black-head cranberry worm" and "yellow-head cranberry worm" formerly officially recognized by it. As the writer finds the newly adopted names satisfactory, he abandons, in this report, the terms "flowed-bog fire-worm" and "dry-bog fire-worm," previously used by him for these insects.

into the spring. If these tests show accurately what actually occurs on the bogs, we seem forced to the conclusion that most, if not all, of the infestation found on a bog in any season immediately following a late holding (until May 20) of the winter flowage comes from the upland that season and does not have its origin on the bog itself.

In the opinion of the writer the temperature of the water is the principal factor in determining the effect of submergence upon the worms (in cocoons), though this has not yet been definitely proved.

The season's records show a considerably higher total parasitism for this insect than was found in 1914, but such a difference may not really have existed, as the study of the parasites was less advanced and less thorough last year than this. The records for this season seem fairly accurate, and the high percentages of parasitism found seem surprising. Special attention was given, as last year, to the three principal parasites: viz., the Braconid (*Phanerotoma tibialis*,[1] which parasitizes the worms), the Ichneumonid (*Pristomeridia agilis*,[2] also a worm parasite) and the Chalcidid (*Trichogramma minuta*, an egg parasite). The *Phanerotoma* parasitism was found to range this season from about 27 to 72 per cent. on dry bogs (without winter flowage), and from almost none to about 22 per cent. on bogs that had the winter flowage held late. The *Pristomeridia* parasitism ranged from about 5 to about 38 per cent. in fruit worms taken from dry bogs, and from none to about 7½ per cent. in those from bogs that had the winter flowage held late. Fruit worm eggs showed a range in *Trichogramma* parasitism of from 42 to about 89 per cent. on dry bogs and from about 12 to about 89 per cent. on those with winter flowage. It will be seen that the parasitism, as a whole, ranged, as in previous seasons, considerably higher on dry bogs than on flowed ones. As a result of these investigations, the writer estimates that all the natural insect enemies (including such predacious forms as spiders and ants with the three parasites here mentioned and other lesser ones not discussed) of the fruit worm took care this year of not less than 97 per cent. of the entire infestation on some dry bogs and of close to 90 per cent. on some flowed

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[1] There is some doubt about this specific name. Mr. A. B. Gahan, of the Bureau of Entomology of the United States Department of Agriculture, regards the species as being new to science.

[2] Specimens of this species were sent to Mr. A. B. Gahan, and he replied concerning them as follows: "Your specimens agree with *Pristomeridia agilis* Cress., except that they are considerably larger. I can find no character to distinguish them from that species other than size. They also appear to agree with the type of *P. euryptychiæ* Ashm. In size your specimens are more like the latter. I am unable to say whether *agilis* and *euryptychiæ* are the same species or not. So far as I can see they are alike structurally, and it may require a knowledge of their biologies to determine whether they are different. *Euryptychiæ* was supposedly reared from a lepidopterous gall maker on *Solidago*, and it would seem a little strange to find the same species parasitizing the fruit worm, although not impossible. The parasitism of *agilis* is apparently unknown. You had perhaps best use the name *agilis* for your species for the present."

In a second letter, written after he had examined the smallest specimens of the species which the writer could find, he added the following information: "Your specimens agree nicely with the type of *euryptychiæ* in size as well as structure, but your smallest specimen is still much larger than the type of *agilis*. I am strongly inclined to think that the two species are synonymous, but would like to have specimens showing better the gradation in size from one to the other before stating that they are the same."

ones. The percentage probably ran considerably below these figures with most bogs, however, especially those with winter flowage.

It will be observed that late holding of the winter flowage appeared to greatly reduce the *Phanerotoma* and *Pristomeridia* parasitism. The writer is inclined to regard this reduction as another rather reliable indication that most of the infestation which appears on a bog, during a season immediately following a late holding of the winter flowage, comes from the upland rather than from the bog itself. Fruit worm moths appear to have fairly good powers of flight, and, if they come from considerable distances to a bog which has been cleared of parasites by the late-held winter flowage, they may succeed in eluding their worm parasitism to no little extent. This reduction of the *Phanerotoma* and *Pristomeridia* parasitism appears to explain the fact that the effect of the late holding of the winter flowage in any season, in its reduction of fruit worm infestation, does not endure into the following season as well as might be desired.

Thirty-five fruit worm cocoons which had been kept in the basement of the station screen-house all winter were opened on May 28 and their contents examined, 30 live and 5 dead worms being found, no pupa of either fruit worm or parasite being present. On June 19, 40 more cocoons similarly cared for during the winter were opened and found to contain: 18 parasite cocoons, part of them being *Phanerotoma* and part *Pristomeridia* (the adults of both parasites emerging between June 26 and July 6); 12 fruit worm pupæ; 1 fruit worm containing a parasite, apparently *Phanerotoma* about three-fourths grown (the worm being torn open to determine this); 1 live unparasitized worm and 8 dead worms. It thus appears that the fruit worm and its two principal worm parasites begin their pupation period at the same time, the change taking place, for the most part, during the first half of June.

As a rule, only one or two of the black eggs of *Pristomeridia* are found in a fruit worm parasitized by that species, but in exceptional cases three or even four are deposited.

Phanerotoma females were induced to parasitize, under observation, eggs of the fruit worm which had been laid in captivity a few hours before. To toughen the eggs so that they might be easily removed for microscopic examination, the berries on which they were deposited were placed at once in commercial alcohol for several hours. When the eggs thus treated were examined, the *Phanerotoma* eggs which they contained were easily found. The latter were elongate and rounded at the ends, nearly transparent, very delicate and pliable, and without any noticeable markings. They usually appeared curved from end to end, as they lay in the host eggs, but were nearly straight when crushed out of the abdomens of the females. The results of this study show that the idea that this parasite was viviparous, advanced in last year's report (page 109), was erroneous.

Fruit worm eggs laid the night of July 19 and parasitized under observation by *Phanerotoma* females the morning of the 20th were ex-

amined microscopically the morning of the 24th, five larvæ of the parasite being found to have hatched. The incubation period of this parasite is certainly, therefore, not longer than four days, and may be considerably shorter than that.

Seven eggs laid by fruit worm moths in captivity some time between 8 P.M. July 18 and 8 A.M. July 19, 1915, were parasitized under observation by *Phanerotoma* females between 9 A.M. and 12 M. July 19, and all of them hatched between 4 P.M. July 26 and 8 A.M. July 28, four doing so before 8 A.M. July 27.

The idea, advanced in the last annual report (page 112), of increasing the natural effectiveness of the Braconid (*Phanerotoma*) parasites by harboring them artificially during the winter is found to be impracticable principally because of the interference of the Chalcidid (*Trichogramma*) parasite, as the latter develops as readily in fruit worm eggs in which *Phanerotoma* eggs have been deposited as in those which have not been attacked by that parasite, and when both parasites attack the same egg the Braconid is destroyed by the very rapidly developing Chalcidid. As the Chalcidid is considerably the more abundant parasite of the two, this interference is sufficient to very largely nullify whatever advantage might be gained with considerable effort in the way suggested.

As is shown by Table 19, the examination of fruit worm eggs from a number of bogs that were reflowed in June and from adjoining ones that were not reflowed seemed to indicate that the flowing in some way not apparent had the effect of increasing the *Trichogramma* parasitism very markedly. This, however, did not appear to result in the corresponding decrease in fruit worm injury that might reasonably have been expected. Possibly the destruction of predacious forms (ants, spiders, etc.) caused by the reflow largely offset the advantage that otherwise would have been obtained from the increase in parasitism.

TABLE 19. — *Effect of June Reflow on Amount of Trichogramma Parasitism.*

Tests.	Examination.	Date of Examination.	Bog.	Date of Removal of Winter Flowage.	Date reflowed (June).	Number of Fruit Worm Eggs examined (both Hatched and Unhatched).	Number of Eggs found Parasitized (both Emerged and not Emerged).	Percentage of Eggs found Parasitized.
A (four adjoining Onset bogs),	1	Aug. 10	1	April 15	Not reflowed.	57	7	12.28
			2	April 15	13th.	20	13	65.00
			3	April 15	15th.	34	23	67.65
			4	April 15	16th.	40	30	75.00
	2	Aug. 16	1	April 15	Not reflowed.	20	5	25.00
			2	April 15	13th.	25	19	76.00
			3	April 15	15th.	27	22	81.48
			4	April 15	16th.	9	8	88.88
B (adjoining Smalley bogs),	1	Aug. 17	1	April 12	Not reflowed.	5	0	-
			2	April 15	5th.	8	7	87.50
C (adjoining Hammond bogs),	1	Aug. 17	1	April 12	Not reflowed.	23	0	-
			2	April 14	3d	14	4	28.57
D (adjoining woods pieces bogs),	1	Aug. 20	1	April 15	Not reflowed.	192	58	30.21
			2	April 15	4th.	63	49	77.77
E (adjoining Bumpus bogs),	1	Aug. 20	1	April 20	Not reflowed.	23	8	34.78
			2	April 20	4th.	70	55	78.57

Winter-flowed bogs that were not reflowed showed a much lower percentage of *Trichogramma* parasitism this season than did the strictly dry bogs (without winter flowage), a condition which perhaps might be expected.

A single specimen of *Megastigma brevicaudis* Rat. [1] and six specimens of an undetermined species of *Syntomaspis* [1] were obtained on July 2 and 3, 1907, from cans containing fruit worm pupæ in the cocoons. It is uncertain whether these Chalcidids were primary or secondary parasites.

In tests conducted the latter part of August, fruit worms fed freely on the following kinds of fruit: swamp blueberries (*Vaccinium corymbosum* L.), dangleberries (*Gaylussacia frondosa* (L.) T. and G.), black huckleberries (*Gaylussacia baccata* (Wang.) C. Koch), apples (*Pyrus malus* L.),

[1] Determined by Mr. A. A. Girault of the Bureau of Entomology of the United States Department of Agriculture. The *Syntomaspis* species could not be identified definitely on account of the present chaotic condition of the genus.

and beach plums (*Prunus maritima* Wang.). They ate black cherries (*Prunus serotina* Ehrh.) very sparingly and the berries of *Viburnum cassinoides* L. not at all. They would not feed in confinement on cranberry leaves.

Bog Management.

The cranberry investigations have now been carried on at the substation for six years. Each year has added something to the knowledge of the problems connected with the growing of this fruit. Many of the findings taken by themselves may seem to have no practical significance, but a stage in the work has now been reached in which the writer is beginning to assemble results in the hope of coming to definite conclusions as to what general changes in bog management, if any, are advisable. Certain ideas in this connection have presented themselves during the past year, and it seems best to discuss some of them in this report. It should be understood, however, that these ideas are not advanced as methods that have been proved to work to advantage. They are brought out here merely for the consideration of Massachusetts growers and in the hope that some will assist in testing them by trying them out on their own bogs.

The interest of the cranberry grower is seldom confined to the control of any one pest or to the solution of any other one problem of the industry as a thing by itself. His main business is not fighting fruit worms, but raising cranberries. The cost of resanding interests him less than the annual net return from his crop. In dealing with the many difficulties connected with the business, he must, if he is to succeed, keep clearly in mind the fact that his main problem — the problem which ultimately will command his every endeavor and around which all his minor interests must center — is really this: *How to make cranberry growing pay the largest possible net return on the capital invested.*

The net return is what is left of the proceeds of the sale of the berries after the cost of production and marketing has been taken out. With a given amount of capital invested and a given acreage under cultivation, this return may be increased either by a rise in the selling price of the fruit, the cost of production and marketing being more or less fixed; or by a lowering of the cost of production and marketing, the selling price being comparatively fixed; or by an increase in the selling price accompanied by a reduction in the cost of production and marketing. To enlarge upon these self-evident facts would be superfluous. They are only a part of the common experience in every walk of life. A man may "get ahead" in the world either by the good fortune of an increased income or by simplicity and economy in living.

In its beginnings, the cranberry industry was in the position of a man blessed with a large income, because cranberries commanded high prices in the markets. Strict economy was not, therefore, absolutely essential to success. During the last few years, however, prices have been comparatively low, and there seems to be no immediate prospect of their

permanent return to higher levels. Cranberry growing has, therefore, now reached the stage where it is necessary to learn to produce the fruit and market it at the least possible expense to make sure of getting satisfactory returns. In other words, the industry is now in the position of a man who must live simply in order to succeed.

Much has been said recently about advertising cranberries extensively with a view to enlarging the market by this means. While the possibilities connected with advertising should not be overlooked, cranberries probably will not be found to be an exception to the general rule that good fruit is its own best advertisement. The growers of other kinds of fruit have made tremendous strides during the past decade in the attention which they give to the quality and condition of their products. Cranberry growers probably will find before long that they must give a like attention to the quality of their fruit if they are to compete successfully. Some of the things which should receive attention in this connection have already been mentioned in the discussion of the storage tests, and many other improvements in the methods of preparing cranberries for market are doubtless possible. The growers could probably do much to extend their market and maintain prices by giving their united attention to these neglected features of the business.

With the general conditions at present attending the cranberry industry brought to mind by the foregoing remarks, the reader will be in a position to more clearly comprehend the main problem of the cranberry grower if it is restated in this way: *How to grow and market cranberries of superior quality with the least possible expense.*

It is in connection with the matter of the reduction of expense in the growing of cranberries that the writer is here about to suggest a new plan of bog management. To begin with, it must be stated that the contemplated changes in methods probably cannot be applied with satisfactory results on all bogs. They may not be feasible on bogs with exceptionally rich bottoms, on account of the tendency to excessive vine growth. They may not be justified on bogs that produce average annual crops of over 60 barrels to the acre. Most bogs, however, do not produce a yearly average of 60 barrels per acre. The suggestions are therefore advanced with considerable confidence that they may be applied by most Massachusetts growers.

The idea of the writer is this: *Growers are unwise in attempting to raise a crop of cranberries from the same area every year.* In so doing they go to needless expense in the care of the bogs and the harvesting of the berries, and frequently throw away money in only partially successful attempts to control the insect pests. *In the opinion of the writer a substantial reduction in the cost of growing cranberries could be effected, without lessening the per acre production, by the adoption of the plan of cropping only every other year as a regular program.*

To begin the argument in favor of cropping every other year instead of every year, the writer will make this statement for the consideration of Massachusetts cranberry growers in general, for their approval or dis-

approval: If any bog that does not yield an average annual crop of more than 50 barrels to the acre fails completely to produce a crop one year (the vines being uninjured), it will, if it is properly cared for and meets with no accidents (such as frost, fire, hail or excessive insect injury), yield the following year at double its average annual rate of production. If this assertion is correct, it goes without question that the plan of cropping every other year may be adopted without fear of reducing the average yearly production of a bog. On the other hand, the writer proposes to show how an actual increase in production might result from such a change.

If the plan of cropping every other year were adopted, it would probably be carried out in somewhat different ways on different classes of bogs. In any case, it would call for the deliberate prevention of the development of a crop, in some way, by the management of the flowage, every other year. *For bogs abundantly supplied with water for reflowage* the writer suggests the following program: —

Begin by resanding the bog some fall after it has produced a heavy crop. This will reduce the tip worm infestation for the following season to a minimum, with the result that, barring accident, a good bud formation will be assured. Hold the winter flowage the following spring until the 20th of May, thus reducing to a minimum the fruit worm infestation already on the bog. Then reflow in June to destroy the first brood of the black-head fire-worm, and again in July to kill out whatever there may be of a scattering second brood. Reflow in full bloom for as long a time as may be necessary to destroy the prospective crop, and, finally, reflow for two or three days some time in August to destroy whatever girdler worms may be at work.

Treated in this way, the bog should be practically entirely free from insect enemies when it is flooded for the winter. It should be free from the fruit worm as well as from the other important pests, for the worms of the previous year will have been drowned out by the late holding of the winter flowage, and whatever subsequent infestation may have come from the upland will have perished or gone elsewhere because of the lack of food on the bog. In addition to being free from insects, the bog should have a maximum bud development for the following year, as the vines, not having been called upon to produce a crop, will be full of strength, and the tips will have had no chance to be injured to any extent by either the fire-worm or the tip worm. Moreover, the good condition of the vines will not have been impaired by the disturbance incident either to the picking of a crop or to resanding. The bog should, therefore, start the following season, the season in which the crop is to be produced, in the best possible condition in every respect. Under such conditions a bog could hardly fail, barring accident, to produce its maximum crop. It will be seen that this program calls not only for the prevention of the development of the crop every other year, but also for the using of every opportunity, in the year of nonproduction, to definitely prepare the bog, in every possible way, to do its utmost the following year.

For bogs which are winter flowed but cannot be reflowed the following plan of procedure is suggested: —

Begin, as before, by resanding the bog some fall when its general condition promises a light crop for the following season, to reduce the tip worm infestation. Hold the winter flowage the following spring as late as may be necessary to exterminate the black-head fire-worm and destroy the prospective crop. Just how late the flowage would have to be held to accomplish these two objects cannot yet be stated, but the 1st of July would probably, as a rule, be about the right date to let the water off. This late holding of the winter flowage would clear the bog of the fruit worm and probably of the girdler also, and the vines, not being taxed by a crop, would have abundant opportunity to develop and bud for the winter; and there should be, as on the bogs with reflowage above discussed, no considerable interference with the bud development from either the tip worm or the fire-worm.

These suggestions may seem unwise on account of the great danger of frost injury on bogs of this class. It is true that, with the proposed changes in the management of these bogs, means of frost protection would have to be provided to insure the crop when produced. Unfortunately, as stated on the first page of this report, tobacco shade cloth has not yet proved its usefulness for this purpose; but, with most bogs of this class, a satisfactory method of protection would probably be afforded by the conservation and proper handling of the winter flowage by means of low dikes and small pumping plants, the bogs being divided and a crop being produced on one part of their area one year and on the other part the next year. The flowage would be conserved on the part which was not producing a crop and would be let on to the part where the crop was being produced, when protection from frost was needed, and then be pumped back again. Handled in this way the winter flowage could be conserved to a far greater extent than is at present possible, for when it was all pumped on to one part of the bog its surface would be greatly reduced and its evaporation consequently be much lessened. It might be necessary in some cases to offset the loss from evaporation and seepage by providing a small accessory water supply by pumping through a small pipe, perhaps for some distance, either from the ground or from a pond or stream. Drainage, while the water was being held, would usually have to be accomplished by pumping.

The possible advantages connected with cropping every other year on flowed bogs may be summed up under the following heads: —

1. *Care of the Bogs.* — The weeds probably would be considerably reduced by the late holding of the winter flowage and a small reduction in expense thus effected.

Resanding every other fall is suggested above as a part of this program. The sanding plots on the station bog have seemed thus far to show that the main advantages of resanding, aside from that of providing a certain degree of frost protection, are its effects in keeping down the tip worm and the

girdler. With the new scheme of management these insects probably might be satisfactorily controlled by the very late holding of the winter flowage, and frequent resanding be thereby rendered unnecessary. As the writer's experiments have shown that resanding has a strong tendency to injure the keeping quality of the fruit, it will be seen that, with this plan, the advisability of the use of sand, after a bog has become well vined over, would be strictly on probation. If resanding could be dispensed with, a considerable saving of expense would be realized.

2. *Treatment of the Insect Pests.* — In the new scheme of management no spraying in connection with any of the more common insect troubles, except on strictly dry bogs, is called for, water being relied upon entirely to control all these enemies on all bogs with winter flowage. Spraying might, of course, have to be resorted to occasionally in dealing with outbreaks of spanworms, army worms or cutworms, and the gypsy moth might also sometimes have to be treated in that way. Spraying is expensive, and the mechanical injury done to the vines and prospective crop in the operation is usually considerable. Moreover, it is at best only a partially successful treatment for any of the flowed bog pests.

Water used in the ways suggested should be entirely effective against all of the commonly injurious cranberry insects, with the possible exception of the fruit worm. Promising as it does to be by far the most effectual means of treatment, it is, at the same time, a general remedy which may be used with a minimum of expense and injury. This change in the methods of insect treatment would in itself, in the long run, make possible a considerable saving in expense.

With the methods of management at present in vogue, the fruit worm takes a considerable toll on most Massachusetts bogs every year. The amount of its injury on a bog in any season depends not upon the number of berries that are being produced, granted there are enough to keep the worms from starving, but upon the number of fruit worms that are at work. It will be seen, therefore, that, if the plan of producing a crop only every other year is adopted, the vines being nearly or completely barren on the alternate years, this insect will thereby certainly be cheated entirely out of one year's feeding every other year. Those who realize how great the average yearly loss caused by the fruit worm is will appreciate how such a reduction in its work might result in a substantial increase in the average quantity of fruit obtained. As the damage done by this insect in the year that the crop was produced would be reduced to a minimum, as already indicated, it having been both drowned out and starved out on the bog the year before, it seems evident that, under this system of management, as inexpensive and as satisfactory a means of control would be had as could be hoped for.

3. *Quality of Fruit produced.* — No one can tell how the keeping quality of cranberries would be affected by the changes in management here proposed until they have been tried out. This is a feature of the program that deserves the most careful investigation and consideration, for, as long as

the matter of spraying for the control of fungous diseases is in abeyance, proper methods of bog management will have to be relied upon as far as possible in producing fruit of superior inherent keeping quality. Much investigation is needed in this connection, especially concerning the bearing which water, in its various uses, has on the development and spread of fungous diseases.

It seems certain that, under this plan, less green fruit would be put on the market, for the winter flowage would seldom be held late on a bog in the spring of a season in which a crop was to be produced, and the berries would always have a growing season of good length before picking time came, as a result. There would also be much less trouble with fruit worms in the early shipments, for there would always be the combination of a maximum crop with a minimum infestation by this pest, this resulting in a great dilution of the infestation.

4. *Expense of Harvesting.* — The cost of picking a small crop is large out of all proportion to the quantity of fruit obtained, for the same area of ground has to be gone over whether the crop is large or small. With the plan of management here proposed, only maximum crops would ever be picked, the expense of harvesting being reduced thereby to a minimum. Moreover, bogs would be picked and also raked after picking only once where now they have to be gone over twice. In the opinion of the writer, the saving gained in this way would, as a rule, hardly be less than 35 cents a barrel.

Possibility of applying the New Plan to Dry Bogs.

Thus far the new proposals have been discussed only as they may apply to flowed bogs. Though the acreage of strictly dry bogs is relatively very small, the changes in question should, nevertheless, be considered in connection with them. It seems possible that these changes may be applied satisfactorily to such bogs, if the bloom can be effectually killed by spraying with iron sulfate or some other chemical. The investigations in this direction have not yet progressed far enough to justify a conclusive report. As has been shown, the fruit worm is very heavily parasitized on such bogs, and it seems only reasonable to suppose that, if it could be even partially starved out every other year, its parasites might thereby receive the assistance they need in order to get the upper hand of the pest sufficiently to reduce it satisfactorily. Careful attention is being given to this apparent possibility of tipping the balance of nature in favor of the cranberry grower. In the opinion of the writer, however, it will eventually be found advisable to replace the cranberry, on all bogs that cannot be winter flowed, with some other fruit-producing plant that does well in acid soil, such as the swamp blueberry (*Vaccinium corymbosum*).

BULLETIN No. 169.

DEPARTMENT OF AGRICULTURAL ECONOMICS.

CONNECTICUT VALLEY ONION SUPPLY AND DISTRIBUTION.

BY ALEXANDER E. CANCE, WILLIAM L. MACHMER AND FREDERICK W. READ.

PART I.

SUPPLY AND PRODUCTION.

Quantities and Regions of Production.

The production of onions is widely distributed. They are grown to some extent, at least, in every State in the Union. Well adapted to commercial production on a small scale the onion industry has shown a steady growth year by year, until, in 1914, with a yield of about 22,000,000 bushels, valued at $20,000,000, it ranked second among the truck crops of the United States.

The geographical distribution of the onion crop in the United States for the year 1909 is shown on the accompanying map reproduced from the report of the United States Census (Fig. 1). A second map (Fig. 3) shows the geographical distribution of surplus production for the year 1914, as reported by the Bureau of Crop Estimates.

A careful study of these maps plainly shows that the commercial onion-growing area is confined to three well-defined sections: first, the tier of States running westward from Massachusetts to Iowa; second, the Pacific Coast States, California, Washington and Oregon; and third, the southern States, Texas and Louisiana. The first and second groups include the States producing late onions, while the third is the home of the Egyptian and Bermuda varieties.

The total onion acreage of the United States in the census year 1899 was 47,981 acres. Seventeen States included in the above groups had

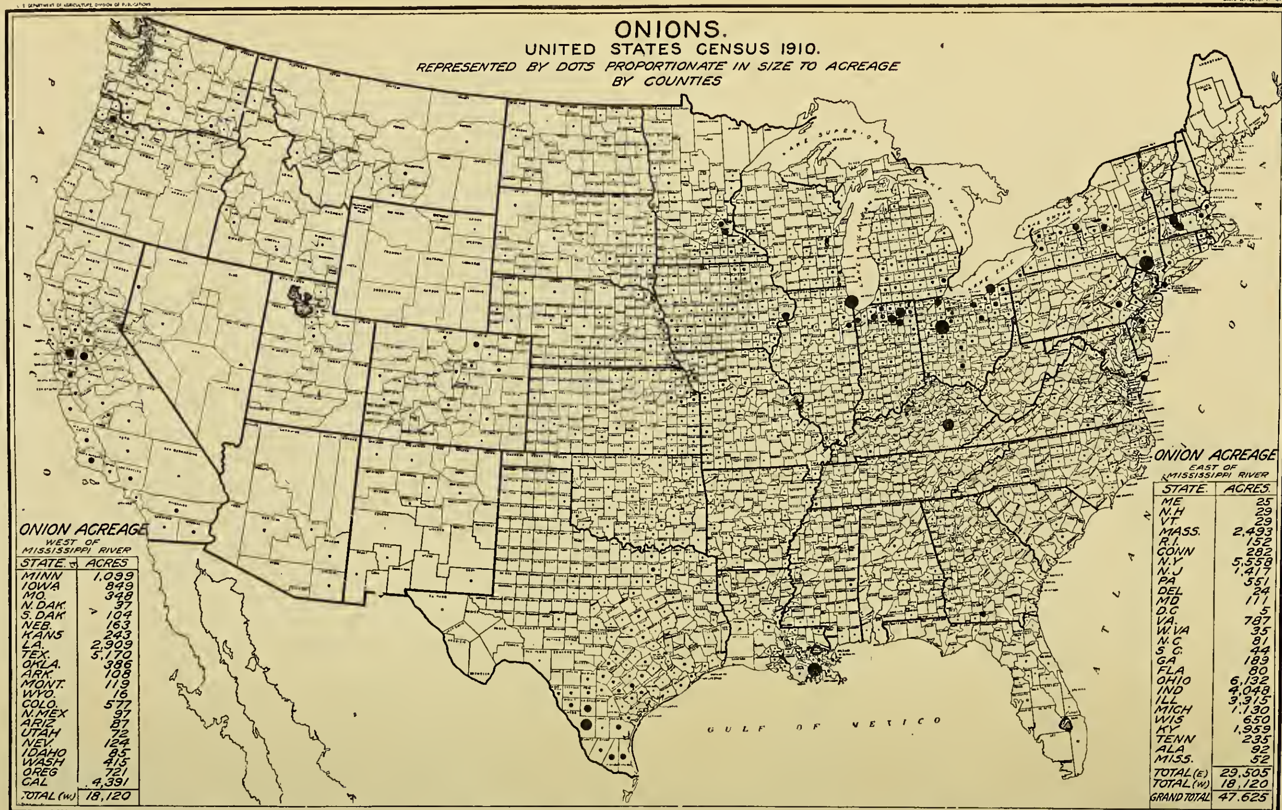


FIG. 1.—Commercially, onions are confined to (1) the States from Massachusetts westward to Iowa, (2) the Pacific coast States and (3) the Gulf States.

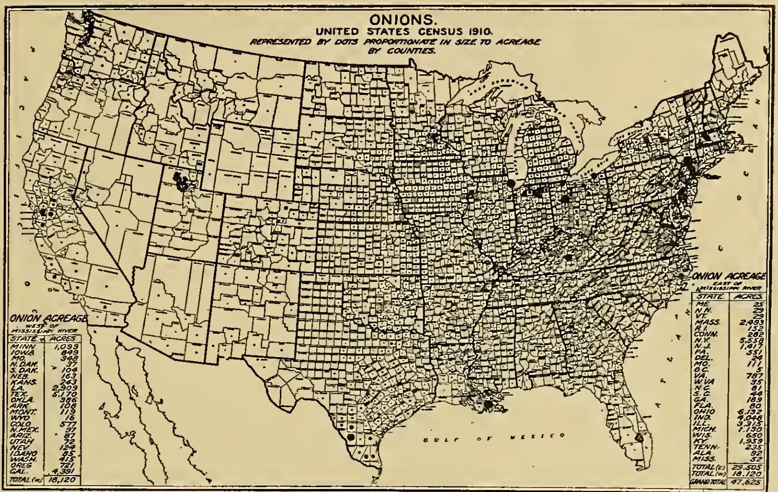


FIG. 2. — The distribution of the onion crop in 1909. This map shows the onion-producing areas in 1909. The dots are proportionate to the acreage.

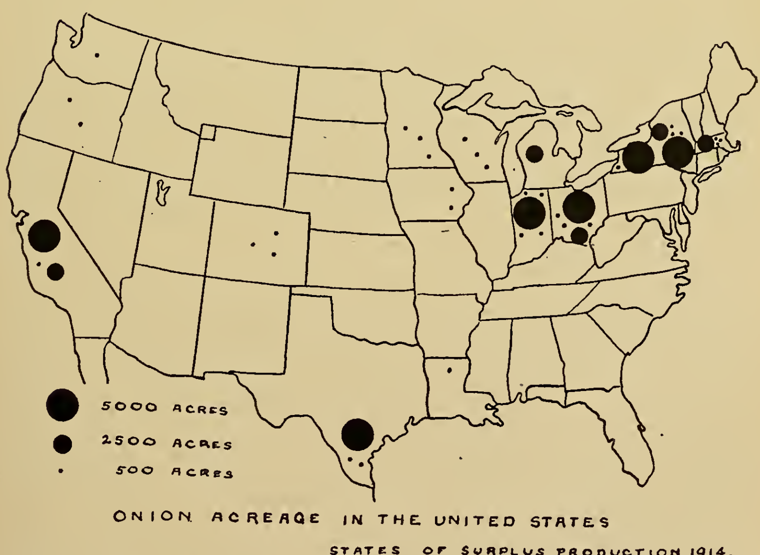


FIG. 3. — The surplus onion States. The relative importance of the various commercial onion-growing States in 1914 is indicated by the black dots. Note the competitor directly west of Massachusetts.

36,599 acres, or approximately 76 per cent. of the total crop. In 1909 the total acreage in the 17 States of largest production was 43,151 acres, or 90 per cent. of the total onion acreage in the United States.

The States of surplus production and their onion acreages were as follows: —

States.	Acreage in 1899.	States.	Acreage in 1909.
New York,	6,033	Ohio,	6,132
Ohio,	5,067	New York,	5,558
Michigan,	2,611	Texas,	5,170
Illinois,	2,563	California,	4,391
California,	2,207	Indiana,	4,048
Indiana,	2,105	Illinois,	3,315
Kentucky,	1,705	Louisiana,	2,909
Virginia,	1,701	Massachusetts,	2,439
Massachusetts,	1,670	Kentucky,	1,959
Louisiana,	1,655	New Jersey,	1,417
Texas,	1,639	Michigan,	1,130
Pennsylvania,	1,505	Minnesota,	1,099
Missouri,	1,383	Iowa,	849
Wisconsin,	1,230	Virginia,	787
Connecticut,	1,206	Oregon,	721
Iowa,	1,195	Wisconsin,	650
Tennessee,	1,124	Colorado,	577
Total acreage,	36,599[1]	Total acreage,	43,151[2]

In 1909 Connecticut, Pennsylvania, Missouri and Tennessee were displaced by New Jersey, Minnesota, Oregon and Colorado.

The total area in onions in 1914 was 54,476 acres in the 12 States of surplus production. Their estimated onion acreage in 1916, excluding Wisconsin, was 31,548. These 12 States produced 69 per cent. of the total onion crop in the United States in the census year 1909. The yield in 1914 was 21,901,000 bushels, as compared with the yield of 9,962,012 bushels for 1915, and the estimated yield of 10,852,873 bushels for 1916. It should be noted that in the above estimate only States producing late onions are included. Texas, with approximately 10,000 acres devoted to onions of the Bermuda variety, is omitted.

[1] Seventy-six per cent. of entire acreage.

[2] Ninety per cent. of entire acreage.

Acreage and Production of Onions in the States of Surplus Production.

States.	Acres.			Production (Bushels).		
	1916.[1]	1915.	1914.	1916.[1]	1915.	1914.
Massachusetts,	3,800	3,923	4,388	1,406,000	1,357,358	2,018,480
New York,	9,389	12,551	14,339	2,722,810	3,602,137	6,567,262
Ohio,	5,302	2,667	9,014	1,834,492	272,034	3,605,600
Indiana,	4,666	3,070	6,801	1,586,440	564,880	2,210,325
Michigan,	873	933	2,633	282,852	223,920	971,577
Wisconsin,	–	1,940	1,384	–	679,000	433,192
Minnesota,	788	1,027	1,572	258,464	385,125	509,328
Iowa,	580	527	976	155,440	210,800	351,360
Colorado,	400	388	1,598	96,000	151,708	559,300
Washington,	613	581	1,112	312,630	232,400	444,800
Oregon,	737	691	735	283,745	276,400	260,190
California,	4,400	5,350	9,924	1,914,000	2,006,250	3,969,600
Total,	31,548	33,648	54,476	10,852,873	9,962,012	21,901,014

General Periods of Shipments.

With the marked expansion of the onion industry the market has shown an equally remarkable growth. Onions are now in the market all the year round. Coming out of storage in the winter, the storage onions are followed by the Bermuda, Spanish, Egyptian and Mexican shipments early in the spring, and later by those from Texas, Virginia, Maryland, Kentucky and Long Island, before the main crop of late onions from the commercial onion-growing sections of the United States reaches the market.

The Texas onion crop usually begins to move the last week in March. Heavy shipments begin about April 10 and continue until the middle of June; the last shipments to New York are made about the last week in July. The Louisiana onions make their appearance the last week in April. After the second week in May practically all the old stock of late northern onions is closed out. From the first of June, Texas, Bermuda, Egyptian and Spanish onions constitute the principal offerings until the beginning of July, when Kentucky onions are shipped north. About the same time Jersey, Maryland, Virginia and some California and Mexican onions appear. During the third week in July, Connecticut Valley "sets" arrive on the New York market. Through August, September, October and November, heavy importations of Valencia and Denia onions make them a competing factor in the principal markets.

[1] Estimated.

Late California and Washington onions do not get to the eastern markets much before the middle of August.

Beginning early in September, Connecticut Valley, Orange County (N. Y.), Ohio and Long Island more than supply the demand. Heavy shipments of these varieties from the field continue until about the middle of November. Connecticut Valley storage onions, as well as those from New York and Ohio, begin to appear in December and continue to move freely through January, February, March and April. Storage onions begin to move in quantity from Michigan and Indiana about the first of February. These supply the markets of the middle west. The southern crop is a competing factor during April and May, and Cubans and Bermudas cut some figure also before the entire crop from the northern part of the United States is consumed. A late southern crop decidedly helps the northern storage men. The duration of the onion-shipping season for the principal States is about as follows: —

Massachusetts,	Middle of July to May 1.
New York,	August 15 to May 1.
Ohio,	September to May.
Michigan,	September 1 to March 20.
Indiana,	October 1 to March.
Wisconsin,	September 10 to March 20.
Minnesota,	October 1 to November 1.
Iowa,	July to April.
Illinois,	October 1 to March.
Colorado,	September to December.
Washington,	September to November 20.
Oregon,	September 7 to March 15.
California,	At intervals throughout the year from different sections.
Texas,	April 10 to July 25.

Reports received by the United States Department of Agriculture from 209 shipping points in the 16 late onion-producing States show that 18,943 cars of onions were shipped in 1913, of which 12,239 cars were moved directly from the field, and 6,695 went into storage at these points for later sale. In 1914 approximately 21,653 cars were shipped from these points, of which 7,879 cars went into storage. In 1913 and 1914 these 16 States produced 75 per cent. of the total onion crop.

Onion Districts in Massachusetts.

The accompanying maps (Figs. 4 to 8), compiled from the Massachusetts Census reports, indicate the distribution of the Massachusetts onion districts at ten-year intervals from 1865 to 1905. Figs. 9 and 10 show the acreage and production of the Connecticut Valley in 1914 and 1915. The data for these were collected in the field by the writers. In 1855 the

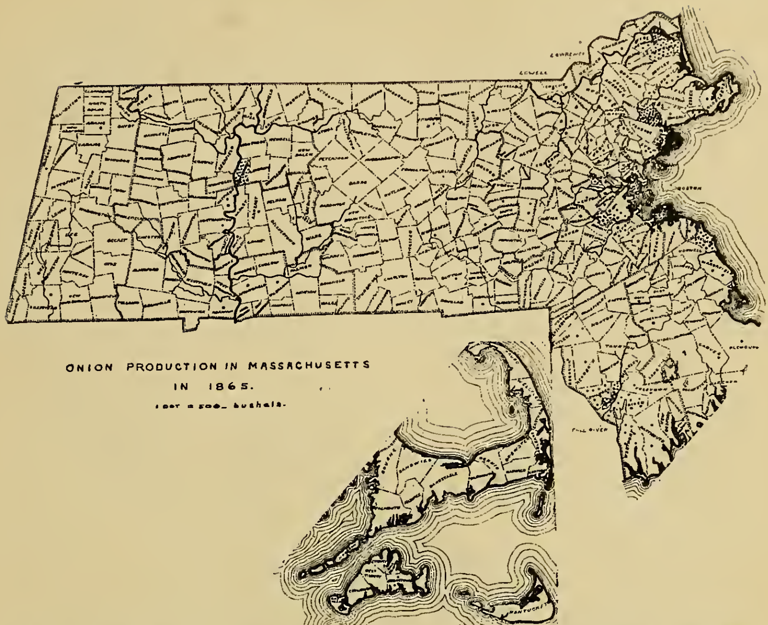


Fig. 4. — The distribution of Massachusetts onions by towns in 1865. Practically none west of the Connecticut River.

Fig. 5. — The Massachusetts onion crop in 1875. It still belongs largely to Essex County.

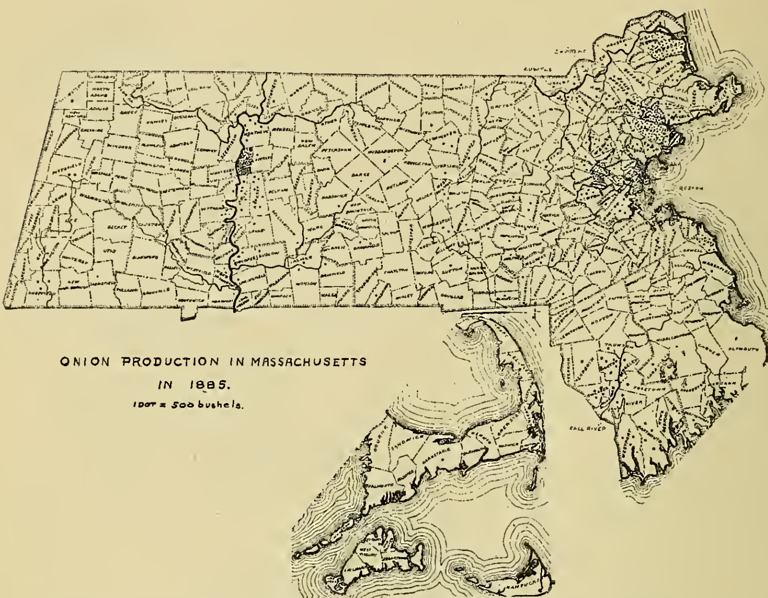


FIG. 6. — The Massachusetts onion areas in 1885. Sunderland shows a decided gain.

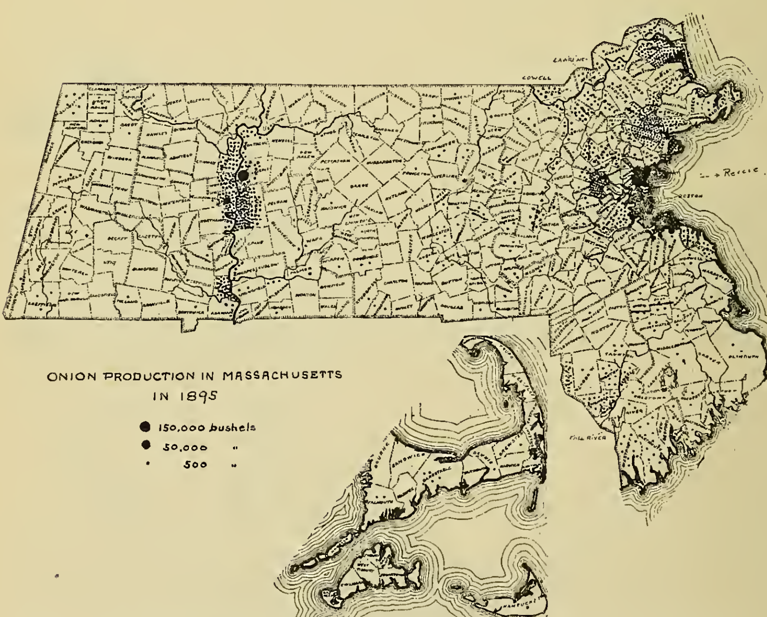


FIG. 7. — The distribution of the Massachusetts onion crop in 1895. Note the development in the Connecticut Valley, both east and west of the river.

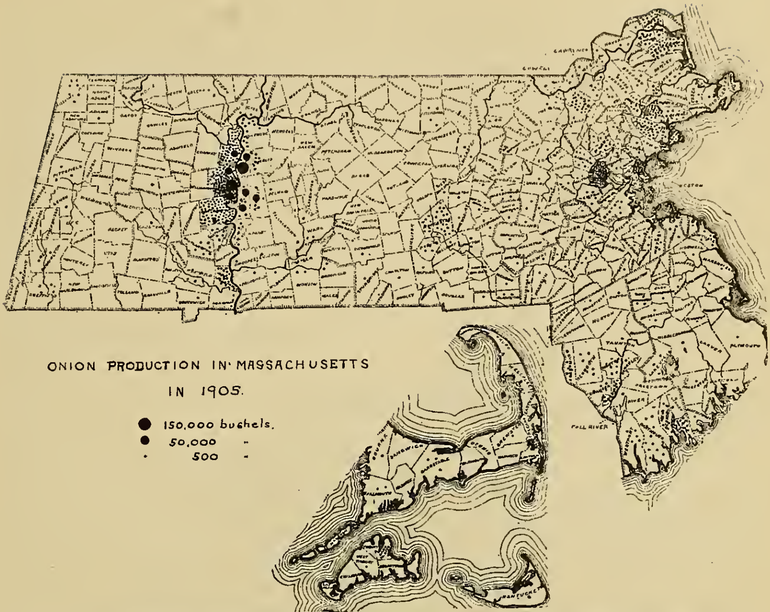
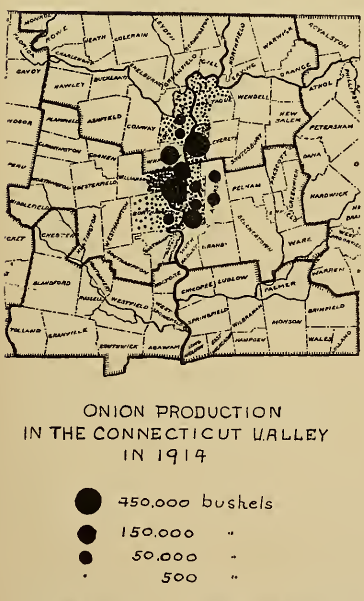
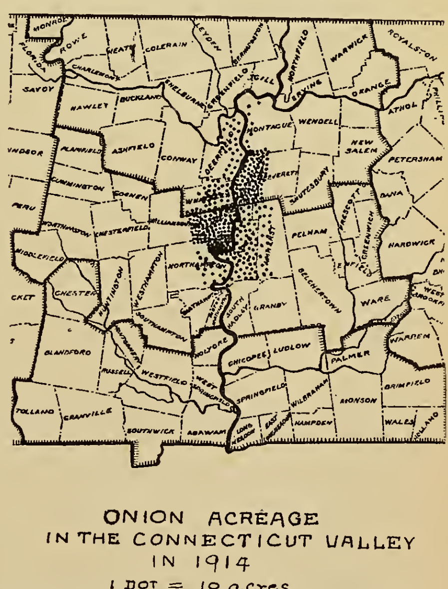


FIG. 8. — The Massachusetts crop in 1905. Note how the industry has shifted west to the Connecticut Valley.





FIGS. 9 and 10. — These maps show the relative importance of the various towns as onion-producing centers in 1914.

total onion acreage in Franklin and Hampshire counties was about 15,[1] as compared with 4,160 in 1915.

These maps show the gradual shifting of the onion-producing area from the eastern part of the State to the valley of the Connecticut River. The rapid development of the industry between 1885 and 1895 was a forecast of future commercial onion growing in Massachusetts.

The growth of the industry in the valley is shown by the diagram below.

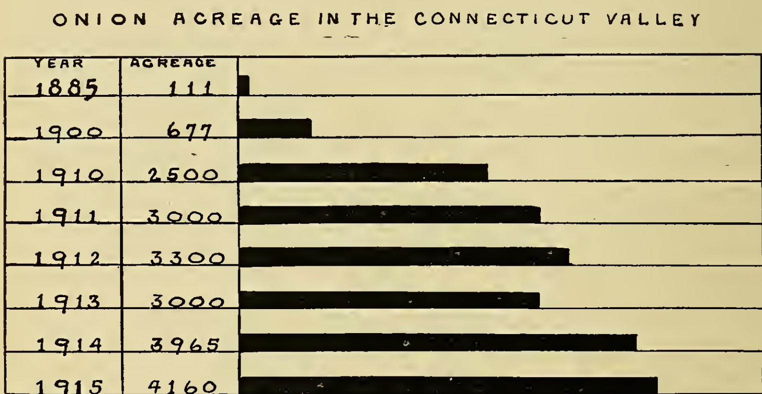


FIG. 11.—Onion acreage in the Connecticut Valley. This chart shows the development of the onion acreage in the Connecticut Valley over a period of years.

[1] The report of the Secretary of the Commonwealth for 1855 gives the following data on the onion industry in Massachusetts:—

COUNTY.	Acres.	Bushels per Acre.	Value.
Barnstable,	34½	151⅚	$4,000 00
Berkshire,	18	289 4/9	1,351 00
Bristol,	21⅝	352⅕	4,170 50
Dukes,	¼	632	106 00
Essex,	521⅚	338½	147,136 00
Franklin,	5¾	189¾	990 25
Hampden,	14½	360¾	3,343 40
Hampshire,	8⅚	420 5/7	2,454 50
Middlesex,	42¾	260⅔	7,486 10
Nantucket,	5	187	516 00
Norfolk,	62⅚	241½	6,490 00
Plymouth,	9	313 7/10	2,066 30
Suffolk,	½	–	–
Worcester,	24½	332⅕	7,336 40
Total,	769⅞	313	$187,446 45

For Hampshire and Franklin counties the distribution by towns was as follows:—

	Acres.		Acres.
Amherst,	1	Conway,	¼
Hadley,	½	Deerfield,	½
Middlefield,	⅛	Gill,	1
Pelham,	½	Greenfield,	1
South Hadley,	5	Monroe,	¼
Ware,	½	Montague,	¼
Ashfield,	2	Northfield,	¼

Connecticut Valley Onion District.

Topographic Features of the Connecticut Valley.

The Connecticut Valley is an elongated basin extending through western Connecticut and Massachusetts. It has a slight southwestern trend, and the Connecticut River flows lengthwise through its central part. At the northern border of Massachusetts its width is about 2 miles. The eastern border extends southward in a generally straight line. The western border, however, is less regular, receding by three successive steps until the valley reaches the width of approximately 25 miles at Hartford.

Throughout the area the walls are comparatively steep and high, and notched by narrow, picturesque gorges through which the Miller and Chicopee rivers enter from the east, and the Falls, Green, Deerfield, Mill, Westfield and Northampton rivers on the west. The surface of the valley is frequently broken by long and abrupt ridges and peaks. The Mount Holyoke range extends from New Britain nearly to Northampton, and then turns east across the valley which it almost completely divides. The Deerfield range extends from Mount Sugarloaf near Sunderland to the village of Gill beyond Greenfield.

In this survey we are concerned only with that portion of the valley lying between the towns of Wendell, Gill and Greenfield on the north and Chicopee and Holyoke on the south, a strip approximately 25 miles in length, with an average width of about 5 miles. This includes the towns of Deerfield, Montague, Sunderland, Whately, Amherst, Hadley, Hatfield and Northampton, the principal onion-producing towns in western Massachusetts.

Onion Soils.

The United States Bureau of Soils recognizes at least fourteen soil types found in larger or smaller areas in the Connecticut Valley. These range in character from clays and heavy loams through fine and coarse grades of sand to gravel. The soil known as the Connecticut meadows, a dark silt loam overlying a silt and very fine sand subsoil which grows heavier downward, is the chief onion soil of the valley. Besides silt both the soil and subsoil contain a considerable quantity of very fine sand and a little clay.

Large areas of this type of soil are found along the Connecticut River at Northampton and extend northwest into Sunderland. Comparatively large areas are also found in the Deerfield Valley and near Northfield. Other important soil types found in the valley, which lend themselves to onion growing when in proper mechanical condition and well fertilized, are the Hartford very fine sandy loam and the Hartford sandy loam.

The total number of acres of cultivated, uncultivated and unimprovable land in the Connecticut Valley onion area in the census year 1905 is shown by the following table. Approximately 56 per cent. of all the

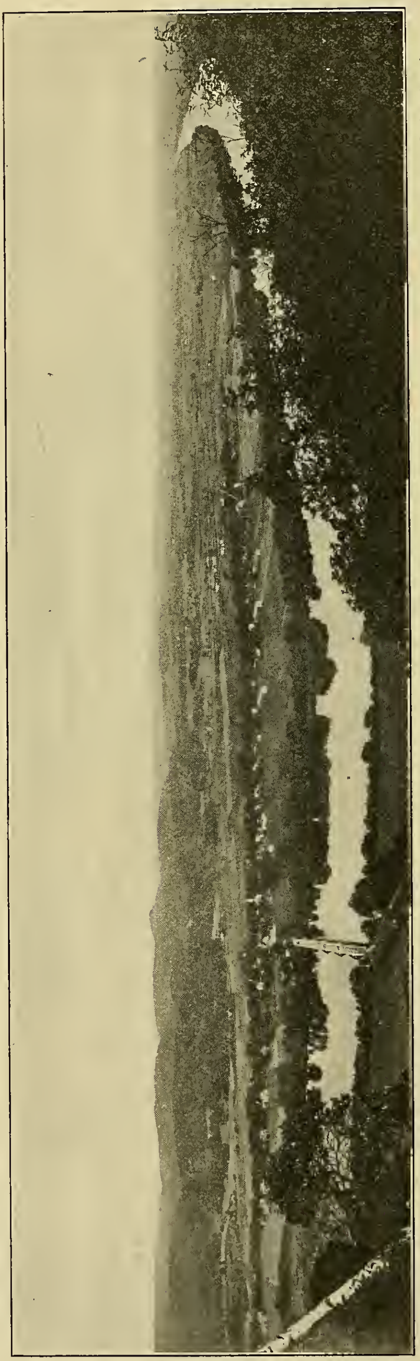


Fig. 12. — The Connecticut Valley, east of the Connecticut River, as seen from Mount Sugarloaf. Over the bridge on the left thousands of bushels of onions are hauled every season from the Sunderland farms and storages to the nearest shipping point, South Deerfield. The Sunderland Meadows, famous for onions, extend from the extreme left of the picture to the sharp bend in the river on the right.

farm land was under cultivation. In 1914 the onion acreage in this area was 3,965, or a little more than 9 per cent. of the cultivated acreage in 1905.

Cultivated, Uncultivated and Unimprovable Acreage in the Onion District of Massachusetts, from the Massachusetts Census of 1905.

TOWN.	Acres Cultivated.	Acres Uncultivated.	Acres Unimprovable.
Franklin County.			
Deerfield,	6,334¼	7,522¼	69
Montague,	5,461¼	5,275½	428
Sunderland,	2,911¾	1,986	60½
Whately,	3,292	4,641¼	188½
Total,	17,999¼	19,425	746
Hampshire County.			
Amherst,	6,719	5,107½	225¾
Hadley,	7,593⅝	3,069¼	177
Hatfield,	4,572½	1,015	21
Northampton,	5,268⅜	4,949	6
Total,	24,153½	14,140¾	429¾

The importance of the valley in onion production is indicated by the fact that 2,955 cars of onions, including "sets," were shipped during the season of 1913–14. In 1914–15 the shipments reached the remarkable total of 3,826 cars, or nearly 2,000,000 bushels. In 1915–16 the shipments were 3,340 cars, a decline of about 500 cars, or 250,000 bushels from the 1914 figures. Farm management surveys of 47 farms in Franklin County and 70 in Hampshire County show that on these farms in 1914 the receipts from onions constituted 31 per cent. and 23 per cent., respectively, of the farm receipts from all sources.

General Marketing Facilities.

The Connecticut Valley is fortunate in location. In close proximity to all the large markets of the North Atlantic States with which it is connected by numerous transportation lines, its shippers experience little trouble in getting their produce to market. Comparatively short hauls and direct routes make for low transportation rates and quick service. The losses in transit from the valley to primary markets for onions of standard quality are small indeed. Very few areas enjoy better general marketing facilities.

General History of Onion Growing in Massachusetts.

As late as 1885, Essex County was the center of onion production in Massachusetts. Onions have been raised in this county from colonial

times, and in 1842 the first premium of $10 was offered by the Essex Agricultural Society for their production. We have evidence that one town raised onions on certain lands for eighty successive years prior to 1849. A history of the town of Danvers, — the most important onion-producing town in Essex County, — written in 1848, says that approximately 120,000 bushels of onions were raised yearly, and that "probably no town in the world raises as many onions as Danvers."

It was not until 1850 that the cultivation of onions began in the Connecticut Valley, in the town of Sunderland. From that date the acreage steadily increased, and by 1875 had spread along the river through Franklin, Hampshire and Hampden counties. By the year 1885 the supremacy of Essex County in the onion industry was seriously challenged, and from 1895 the Connecticut Valley became indisputably the onion area of Massachusetts. Until the census year 1905 the town of Sunderland maintained first position both in acreage and in production, but since that time it has been outstripped by Hatfield.

The nationality of western Massachusetts farmers has changed considerably, particularly in the onion and tobacco industries. In 1853 in the four western counties — Berkshire, Hampshire, Hampden and Franklin — foreign laborers constituted less than one-fifth of the total, and those were mostly Irish and French. In the eastern part of the State by far the larger number of hired farm laborers were foreign. In the counties of Norfolk, Middlesex and Essex more than three-fourths were foreign. The influx of Poles, Lithuanians and Slovaks, which had fairly set in by 1890, has had a direct effect on the growth of the onion and tobacco industries in the Connecticut Valley. Since that date the proportion of these races has been steadily increasing and the onion industry, which calls for a large amount of hand labor which the foreigners are willing and able to give, has grown steadily. In 1895, 16 per cent. of the foreign population in Deerfield, Sunderland, Montague, Whately, Amherst, Hadley and Hatfield were born in Poland, Austria and Russia. In 1905 the proportion had grown to 44 per cent. A seed firm doing a large business in the valley reports that its list of customers in 1895 contained the names of only two foreigners; in 1915 the total number of customers in the same territory was 198, of whom 145 were foreign born.

There has been no striking change in the methods of growing onions. In early times the seed was planted by hand; but since the introduction of onion culture along the Connecticut River the hand seeder and hand cultivator have come into use. Adaptations and improvements of these two implements have been practically the only change worth noting in the culture of the onion.

In 1916 the eight-row horse seeder made its appearance. These gang seeders are proving very satisfactory. They make possible at least eight rows that are sown alike and spaced evenly, and with the tank attachment for carrying formaldehyde solution an effective treatment for smut may be applied directly when the seed is sown.

Economics of Production. Tenure of Land.

In Franklin, Hampden and Hampshire counties, in 1910, 94 per cent. of the farms were operated by owners, 5 per cent. by cash tenants and 1 per cent. by share tenants. In the same year 93 per cent. of all Massachusetts farms were operated by owners, 6 per cent. by cash tenants and 1 per cent. by share tenants. Practically no change has occurred in this

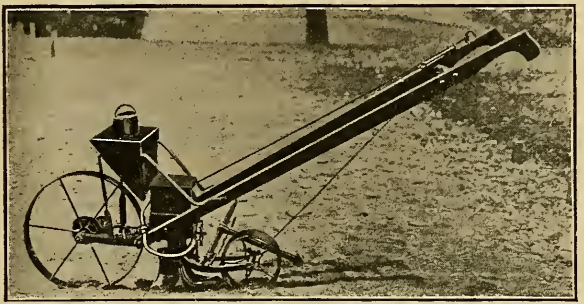


Fig. 13. — A Planet, Jr., hand seed drill. This type of seeder is widely used among Massachusetts onion growers. Note the tank for carrying formaldehyde solution.

Fig. 14. — The new eight-row horse seeder. This drill is equipped with a 21-gallon tank for carrying formaldehyde solution. It was first used by Oscar Belden & Sons of Hatfield, Mass., in 1916.

regard since 1880. In fact, Massachusetts exhibits an exceptionally high percentage of ownership.

The census figures on the percentage of tenancy in the Connecticut Valley are misleading when the onion crop alone is considered. In Massachusetts the proportion of tenants engaged in the growing of onions is much greater than in growing any other crop; hence, considering this

industry alone, the percentage of tenants is much greater than the ratio of tenants to all farms. Most of the tenant farms are operated by immigrant families, the women and children doing much of the hand labor required for growing the crop. Very little capital is necessary to grow onions on shares, which makes this form of tenure attractive to foreigners with small means or large families.

Two general types of tenancy are found in the valley. The one may be called share rental and the other cash rental. The terms of share rental may vary widely, but the rent is usually half the crop. Under this

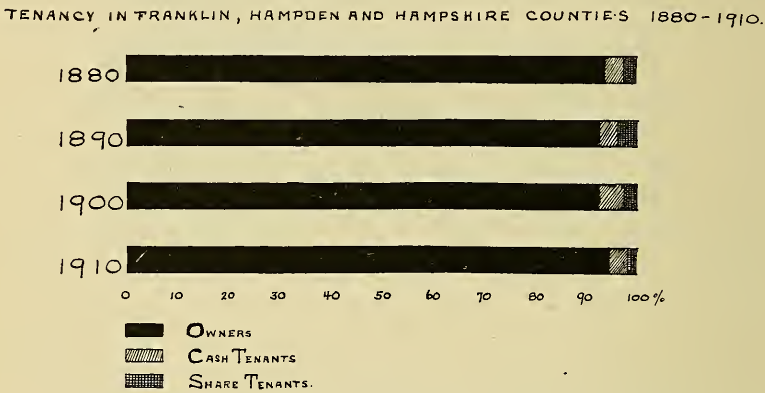


FIG. 15.

form the owner pays for the fertilizer and frequently for half the seed, in addition to supplying all the machinery and all the labor necessary to prepare the seed bed. He also hauls his share of the onions to market. All that the renter furnishes is his share of the seed which he may buy on credit, and the labor required to grow and harvest the crop which calls for a very few inexpensive tools.

The cash rent paid for the most desirable onion land varies from $30 to $50 per acre. Under this form the landowner furnishes nothing but the land. The cash tenant requires some capital; generally, however, he experiences little difficulty in buying his seed and fertilizers on credit. By beginning as laborers and taking advantage of these forms of tenure many enterprising immigrants, especially Poles, have been able to save enough to become farm owners.

Soils and Climatic Conditions.

Onions may be grown successfully under a wide range of climatic and soil conditions. During the early stages, however, cool weather and a good deal of moisture are essential. Later, a reasonable degree of heat, together with a dry soil and atmosphere, are needed for the ripening and proper curing of the bulb. The climatic data shown in Tables I and II are illuminating.

TABLE I. — *Precipitation (in Inches)*.[1]

	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Annual.
1889-1913 (mean),	3.47	3.28	3.99	3.01	3.74	3.22	4.34	4.17	4.07	3.69	3.20	3.59	43.76
1914,	3.72	3.36	5.52	6.59	3.56	2.32	3.53	5.11	0.52	2.09	2.62	2.89	41.83
1915,	6.52	7.02	0.12	3.99	1.20	3.00	9.13	8.28	1.37	2.89	2.20	5.86	51.58
1916,	2.56	5.27	3.97	3.69	3.21	5.34	6.85	-	-	-	-	-	-

TABLE II. — *Hours of Bright Sunshine*.[1]

	January.		February.		March.		April.		May.		June.		July.		August.		September.		October.		November.		December.		Year.	
	Mean.	Mean Per Cent.	Mean.	Mean Per Cent.	Mean.	Mean Per Cent.	Mean.	Mean Per Cent.	Mean.	Mean Per Cent.	Mean.	Mean Per Cent.	Mean.	Mean Per Cent.	Mean.	Mean Per Cent.	Mean.	Mean Per Cent.	Mean.	Mean Per Cent.	Mean.	Mean Per Cent.	Mean.	Mean Per Cent.	Mean.	Mean Per Cent.
1889-1913,	137	46.6	159	53.4	189	50.9	221	55.0	224	49.5	253	55.4	260	56.3	228	53.3	197	52.9	165	48.4	122	41.4	130	45.9	2,304	51.7
1914,	95	32.0	178	60.0	170	46.0	194	48.0	324	72.0	283	62.0	241	52.0	209	49.0	246	66.0	164	48.0	113	38.0	160	57.0	2,377	53.0
1915,	144	49.0	115	39.0	290	78.0	223	56.0	273	60.0	269	58.0	191	41.0	152	35.0	181	49.0	162	48.0	118	40.0	106	38.0	2,224	50.0
1916,	140	48.0	140	47.0	217	58.0	123	31.0	181	40.0	156	34.0	184	40.0	-	-	-	-	-	-	-	-	-	-	-	-

[1] Massachusetts Agricultural Experiment Station, Bulletin 153, and Massachusetts Meteorological Bulletins 301–331.

Frosts.[1]

Year.	Last Frost.	First Frost.
1913,	May 15	September 10
1914,	May 16	September 28
1915,	May 20	September 23

These tables are inserted to give the reader some idea of the climatic conditions prevalent in the Connecticut Valley. For comparative purposes the twenty-five years' mean (1889–1913) is also given. The crop year 1914 was ideal for onions, judged from the standpoint of yield and keeping quality, while 1915 was decidedly below the average in these respects. Note the departures from the normal during the growing and harvesting season, both in precipitation and sunshine.

Onions are now grown successfully in the United States on three general types of soil.

1. *Clay and Alluvial.* — These soils, though fertile, usually need a considerable amount of manure to lighten them. They are the soils of the river valleys and delta regions near the coast. Spanish and Egyptian varieties are almost exclusively grown on soils of this type.

2. *Muck and Peat.* — These are found in large areas throughout the States bordering the Great Lakes. They require considerable attention before they are suitable for onion growing. On this type are grown most of the Orange County (New York) and Ohio onions. There are still very large tracts of this soil awaiting reclamation.

3. *Sandy Loams.* — These soils, especially when overlying a well-drained subsoil as in the Connecticut Valley and with a liberal application of commercial fertilizer, are ideal for onion growing. The silt loam known as "Connecticut meadows" has a decided advantage over others in that the onions mature better, become much harder and are of better keeping quality. The onions grown on this soil are found on the market in March and April, and even as late as May.

In the Connecticut Valley the physical character of the soil determines the specific crop to be grown, and the adaptability of those soil types to such special crops has been the principal basis of land valuation for the last half-century. The principal competing crops are tobacco, corn, hay and potatoes.

There is still much land in the towns of Northampton, Amherst, Deerfield and Montague which might easily be put into condition for successful onion growing. In Hatfield, Sunderland and Whately, however, practically all the available land suitable for profitable onion growing is now devoted to the crop and very little extension of the present area is possible.

[1] Massachusetts Agricultural Experiment Station, Bulletin 153, and Massachusetts Meteorological Bulletins 301–331.

Extent of Industry.

In 1905 (the latest statistics available) the number of growers in the valley was 850, and the number of bushels grown was 782,860, making an average production of 925 bushels per grower. Ten years before, in 1895, there were but 372 growers raising 310,309 bushels, representing 856 bushels per grower.

Methods of Culture.

Under very favorable conditions with proper fertilization, tracts of land may be continuously cropped with onions, but it seems better, and in some sections of the valley absolutely necessary, to practice some system of crop rotation. This will often prevent the land from becoming infested with disease and insect enemies.

The methods of fitting land for onions vary somewhat with the character of the soil, the locality and the season. As a rule, Connecticut Valley growers plow in the autumn, but defer it as late as possible. Fall plowing is especially desirable, because the ground can be worked earlier in the spring, and, in this section, it is necessary to get the seed and sets into the ground at the earliest possible date.

For surface fitting in the spring, a disk harrow or plow is used for breaking up the soil. This is followed by an Acme harrow or any device which will thoroughly pulverize the surface. To give the final smoothing to the soil before planting, a device called the Meeker harrow is used. This consists of four rows of small disks set in a rectangular wooden frame, two rows at either end. Across the middle of the framework is fastened a board tilted slightly from its vertical position for the purpose of smoothing the ground. The harrowing, disking, rolling and dragging are continued until the soil is smooth and mellow to a depth of 4 or 5 inches. Usually not less than a full day's labor of man and team is required to prepare an acre of onion land for seeding.

The return per acre justifies the grower in using a large quantity of high-grade fertilizer. In the Connecticut Valley where stable manure is not very plentiful growers resort almost wholly to commercial fertilizers. Some growers find it desirable to purchase the ingredients and mix their own chemicals, but the majority use ready-mixed fertilizers. No general formula can be given, because the natural character and needs of the soil, together with its previous treatment, are the only safe guides as to proportions and quantity. The average cost per ton through the valley in 1914 was $33.92, and the average application, 3,000 pounds to the acre. Successful growers advocate applying fertilizer early in the spring, so that it may be thoroughly incorporated with the soil by the various fitting operations.

Seed and Sets.

Connecticut Valley onions are propagated both from sets and from seed. Sets are small onions produced from seed thickly sown in comparatively poor soil. These small onions are planted the following spring

and mature full-grown onions at least a month earlier than onions grown from seed. Owing to the cost of the sets, perhaps averaging about $56 an acre, and their setting, a comparatively small acreage is thus grown — in 1914 about 225 acres, belonging chiefly to the larger growers. Most of the onions are propagated by sowing the seed in rows in the field where the crop is to mature. Naturally, only seed with a high germinating test should be used. Over half of the seed now used in the Connecticut Valley is California-grown. A large percentage of the remainder is grown near Milford and Wethersfield, Conn.

Fig. 16. — A good field of Connecticut Valley onion seed as it appears just before it is harvested. Heavy winds and hail spell ruin for this enterprise.

Very little seed has as yet been grown in the Connecticut Valley, but several demonstration plots have proved conclusively that it can be profitably raised. One prominent seed house doing business in the valley harvested from a plot of approximately 1 acre 430 pounds of marketable seed. This is about one-third to one-fourth less than the California yield under favorable soil and weather conditions. In 1915 good seed cost the grower about $1.30 per pound and $1.50 on credit. Generally from 5 to 6 pounds of seed are required to sow an acre. The seed is sown as early in the spring as the soil can be brought into proper condition, usually about the first week in April.

Varieties.

In the selection of varieties, both soil conditions and market requirements must be considered. That variety should be selected which has the greatest number of desirable characteristics, or commands the best price in the market for which it is grown.

Over 95 per cent. of the onions grown in the Connecticut Valley are of the Yellow Danvers variety. This variety, a bulb of medium size, globular in form, hard and compact in structure, with a close thin skin and a small neck, is very productive. It has excellent keeping qualities and is, therefore, well adapted for storage and shipping purposes. While it has an excellent flavor, and under existing conditions is undoubtedly the best general variety for the Connecticut Valley, it is, nevertheless, far inferior in texture, flavor and keeping quality to the Spanish and the Denia varieties.

A small acreage of the Red Wethersfield variety is also grown and good yields are reported. The bulbs are large and keep well. The skin is deep purplish-red, the flesh purplish-white, somewhat coarser and of stronger flavor than the yellow onions. This variety is preferred to Yellow Danvers in some markets, especially those patronized by the French, but in most eastern markets the price is much lower.

Weeding.

Usually the first cultivation comes about three weeks after the seed is sown, the purpose being to loosen the soil, which is always more or less packed during the seeding and by rains, and to destroy all weeds. Three to seven weedings and numerous workings with hand implements are required, depending very largely upon the condition of the land and the season. Each weeding costs from $6 to $8 per acre, according to the wages paid and the difficulty of weeding. The implements employed are the onion hoe, shove hoe, hand cultivator and weeding hook.

Economic Factors.

On an average, one man can take care of about 3 acres. This amount may be considerably increased if he is assisted by his wife and children. Growers who plant from 10 to 75 acres must necessarily employ a large force of hired men, whose time is usually distributed between the onion and tobacco crops, a number being retained throughout the year, while others are employed for the season. During the planting and harvesting additional day laborers must be hired at wages ranging (in 1915) from $1.50 to $2 per day, without board.

In growing onions the amount of land per man is relatively small. Well fertilized and cultivated, a small acreage is more profitable than a larger area only moderately well cared for. Good onion land is worth from $300 to $500 per acre, and much labor is necessarily required in

growing the crop, as well as a large outlay for fertilizer; hence the necessity for a small acreage per man, intensive culture and a large yield. The outlay for equipment is a small item, because most of the labor is done by hand.

Harvesting.

The harvesting of onions from sets begins about the second or third week of July, varying somewhat with the season and the condition of the market. In 1915, for instance, when the Texas crop held on long into the summer, the harvesting of sets was delayed for fully a week awaiting a better market. Even then they were sold to dealers for 75 cents per 100 pounds, and by them in turn for 90 cents to $1 to the trade. The preceding year the conditions were just the reverse; the price was $3 to $5 per 100 pounds, causing the crop to be harvested very early and rushed onto the market.

The processes of harvesting are pulling, clipping, drying, screening and bagging. In general, the harvest season extends from about August 20 to the middle of October.

While lifting machines are used to some extent for pulling onions, by far the greater number are removed by hand. This is undoubtedly the better way, because the present type of machine is likely to cut the bulbs or to cover the roots with soil. If allowed to lie covered a few days new roots may start and render the bulb worthless.

The time for pulling onions varies to a certain extent among the growers. A good many hold that onions should not be taken from the ground until the tops have bent over by their own weight and are pretty well dried. Ripened in this way, onions are practically cured in the ground, and after their removal may be clipped and marketed or placed in storage almost immediately. There are others, however, who advocate pulling the onions while still somewhat green, in fact, just as soon as they have attained full size. Such onions, these growers believe, should be clipped as soon after pulling as possible and immediately put into storage. Under these conditions they will keep their outer skins, very seldom develop roots in storage, and with curing become solid bulbs of excellent color. All growers agree that onions must not be allowed to become too ripe before pulling on account of the tendency to take root again, especially if the season is wet.

It would seem, then, that the time of marketing should, in part, determine the proper time for pulling. If they are to go on the market immediately the onions should be allowed to get fairly ripe. After the roots have become dry they can be clipped, screened, bagged and marketed. Onions thus treated will look better and, therefore, find a more ready sale than if not so ripe or less well cured. However, onions should not be allowed to lie on the ground very long, because the hot sun and rain are liable to destroy the color, crack the outer skin and render them less salable. On the other hand, experienced storage men agree that if they are to go into storage they should be pulled rather green and allowed to cure in storage.

They may not look so well when put in, but they keep better, and the desirable color comes with curing.

The amount of work connected with harvesting a crop often makes it necessary to leave onions on the ground for several days. This will not hurt them necessarily, if they are not clipped, but clipped onions that remain on the ground overnight are likely to absorb moisture and become spongy.

A few of the growers have been cribbing their onions with very good results. This is done by putting the onions directly from the field, often without topping, into 2½-bushel crates. These crates are then placed two crates wide and four crates high in a crib similar to the ordinary corn crib, but open at the sides. They are left there until the latter part of November, and then removed into the ordinary storage. The open sides of the crib allow the wind to blow right through the onions. This dries them thoroughly, and the bulbs cure down into hard onions of excellent color. Onions cared for in this way usually sprout very little in the regular storage, and the shrinkage is considerably reduced. The objection to this method is that it is rather expensive due to the extra labor required. In a general way, it would seem that the Ohio method of crating the onions and stacking them in the field would be preferable.

Cost of Production.

The cost of raising an acre of onions in 1915, based on the best figures obtainable, and the items among which the cost is distributed, are as follows: —

Cost of Producing an Acre of Onions to the Landowner.

Value of land,			$300 00
Rent (calculated at 5 per cent.),			$15 00
Tools, etc.: —			
Seeder,	$13 00		
Hand cultivator,	4 50		
Onion hoe,	75		
Shove hoe,	1 50		
Shovel,	1 50		
Screen,	13 50		
Baskets (2),	1 00		
Shears,	75		
Rake,	50		
		$37 00	
Horse implements: —			
Plow,	$45 00		
Disk harrow,	25 00		
Acme harrow,	12 50		
Meeker harrow,	24 00		
Fertilizer sower,	40 00		
		146 50	
Total investment in farm equipment,		$183 50	

Interest on value of equipment (calculated per acre),	$2 97
Taxes on land valuation $60, rate $18 per $1,000,	1 08
Depreciation of equipment per year (calculated per acre),	3 40
Fertilizer, 3,000 pounds at $34 per ton,	51 00
Seed, 6 pounds at $1.30 per pound,	7 80
Labor, for fitting land and sowing fertilizer: —	
11 2-horse hours at 50 cents,	5 50
4 hours' drilling in seed at $1.75 per day,	70
Labor, for tending crop: —	
21 days' weeding, 4 days' shove hoeing, 5 days' cultivating, } 30 days at $1.75,	52 50
Labor, pulling: —	
1½ days at $1.75,	2 63
Total cost per acre to landowner,	$142 58
Total cost per bushel (460 bushels per acre),	31

Cost of Producing an Acre of Onions to the Cash Tenant.

Land rental (average),		$38 00
Tools, etc.: —		
Seeder,	$13 00	
Hand cultivator,	4 50	
Onion hoe,	75	
Shove hoe,	1 50	
Shovel,	1 50	
Screen,	13 50	
Baskets (2),	1 00	
Shears,	75	
Rake,	50	
	$37 00	
Interest and depreciation on investment in tools (calculated),		2 10
Fertilizer, 3,000 pounds at $34 per ton,		51 00
Seed, 6 pounds at $1.45 per pound (credit),		8 70
Labor, for fitting land and sowing the fertilizer: —		
11 2-horse hours at 50 cents,		5 50
4 hours' drilling in seed at $1.75 per day,		70
Labor, for tending crop: —		
21 days' weeding, 5 days' cultivating, 4 days' shove hoeing, } 30 days at $1.75,		52 50
Labor, pulling: —		
1½ days at $1.75,		2 63
Total cost per acre to renter,		$161 13
Total cost per bushel (460 bushels per acre),		35

Yields.

Despite rather striking variations by years, the average yield per acre of Connecticut Valley onions has measurably increased in recent years, due to better farm practices and effective control of some onion diseases.

In 1913, on 3,849 acres planted, the average yield per acre was 336 bushels; in 1914 the average yield per acre was 460 bushels, with an acreage of 3,965. This was the highest average reported by the Bureau of Crop Estimates for the 12 States of surplus production. In 1914 the average yield of 86 growers scattered through Franklin and Hampshire counties was 520 bushels per acre.

Of the 86 growers, from whom data were obtained by personal interview in 1914, 27 growers in Sunderland reported an average yield per acre of 572 bushels; 5 growers in Whately, 398 bushels; 5 in Deerfield, 248 bushels; 6 in South Deerfield, 317 bushels; 21 in Hatfield, 600 bushels; 11 in Hadley, 521 bushels; and 11 in Amherst, 485 bushels per acre.

The following table presents the figures obtained from the 86 growers who were personally interviewed by representatives of the college: —

Town.	Number of Growers.	Total Acreage.	Total Production.	Average Yield per Acre (Bushels).
Sunderland,	27	315.75	180,575	572.0
Whately,	5	50.75	20,200	398.0
Deerfield,	5	58.00	14,396	248.0
South Deerfield,	6	53.00	16,776	316.5
Hatfield,	21	234.33	140,707	600.0
Hadley,	11	42.50	22,143	521.0
Amherst,	11	79.75	38,640	485.0
Total and average,	86	834.08	433,437	520

Part II.

Marketing the Crop.

Preparation for Market.

The onions of the Connecticut Valley are marketed as sets and as seed onions. These are graded into *picklers* and *primes*, the latter including all bulbs exceeding $1\frac{3}{8}$-inches in diameter.

Topping and Curing.

Very little attention is given to the curing of onions grown from sets. When the season is at its height, it is not uncommon for onions that are pulled in the morning to be in the cars on the way to market by evening, it being necessary only to dry the roots a little. The late or seed onions, however, especially if they are not put into storage, are allowed to lie on the ground usually in windrows for a period varying from a few days to two weeks before topping. There is danger from too much exposure to sunshine; hence the bulbs are stirred frequently with wooden rakes, but even then some injury to color, outer skin and quality results.

Most of the onions are topped or clipped in the field with ordinary sheep shears. Topping machines are sometimes employed, the onions being hauled from the field to the storage and there run through the topper either immediately or when they are removed from storage in the winter. These machines remove the tops, grade the bulbs and deliver them into crates or bags. Unclipped onions take up a little more room, but storage men usually agree that they keep as well if not better than topped onions.

Screening and Grading.

When the topped onions are thoroughly dry they are cleaned and graded by screening them. This is done in the field, and for efficient work with a medium acreage eight or nine men are required. The men are distributed as follows: two shovel the onions into bushel baskets; two carry them and dump them on the screener; two shake the screener; one takes off the bags; one weighs them; and another sews the bags up. When the onions are screened for storage, the last two men are not needed.

The screen, which has come into use within the last ten years, has a sloping bed of slats with $1\frac{3}{8}$-inch openings, and sides 6 to 8 inches high. The distance between the slats was at first $1\frac{1}{2}$ inches; a few years later it was reduced to $1\frac{3}{8}$ inches; and about two years ago by some farmers to $1\frac{1}{4}$ inches. This opening should not be made smaller. Practically all

contracts made between grower and dealer call for onions screened over $1\frac{3}{8}$-inch screens.

The onions that pass through the screen are called *picklers*. Those that pass over the screen are caught in bags and crates and sold as *primes*. The picklers are frequently rescreened over a small screen to free them from dirt and the very small onions.

Since screening is the only means of cleaning and grading onions shipped to the market directly from the field, too much care cannot well be exer-

Fig. 17. — Screening onions in the field. Note how it delivers primes into the sacks. Carefully screened onions help the Connecticut Valley onion trade; poorly screened onions damage it.

cised by the grower in this operation. The men who operate the screen should be given time sufficient to pick out the dirt and poor onions. Overloading the screen and failure to keep the openings free from dirt and onions are practices entirely too common among growers.

Practically all the buyers and storage men of the Connecticut Valley agree that a third or intermediate grade, although unnecessary for the present demands of the trade, might be made with profit. This is also

the view held by the commission men and wholesale dealers of the Boston market. All distributors find fault with the grading done by the farmers. Onions are frequently graded so poorly that it becomes necessary to rescreen an entire consignment to bring it up to the standard. This, of course, entails much additional expense, and is one reason why some farmers find it difficult to sell their product at the best prices. *Careful grading is not only desirable, but it pays.* Again, whether onions are shipped immediately or placed in storage, they should be perfectly dry when put into the bags or crates.

Labor required to prepare Onions for Market.

One man can top by hand from 50 to 70 bushels of onions per day. Men who do this work receive $1.75 per day, or by piece work 4 cents a bushel. Unclipped onions usually sell for 4 cents less per bushel than the quoted price. A gang of eight or nine men will screen and bag from 1,000 to 1,200 bushels in a day. These men receive $1.75 per day, without board, or, if employed by the month, from $35 to $45, without board, making the cost of screening and bagging approximately 1.7 cents per bushel.

Hauling.

The average initial haul from field to car or to storage is approximately 2½ miles. The average 2-horse load contains from 60 to 65 bags of 100 pounds each, so that a car of 500 bushels may be filled in a day by making four trips. For a team and driver farmers pay $5 per day; for the use of their own teams they should allow not less than $4 a day. This makes the cost of hauling to the car or storage about 1.1 cents per bushel. Thus, the average cost of preparing a bushel of onions for market and putting it into the car or storage is about 6.8 cents, distributed as follows: —

Topping,	$0 040
Screening,	017
Hauling,	011
	$0 068

Adding 31 cents, or the cost of producing a bushel of onions, gives a total of 37.8 cents, the cost delivered at storage or depot.

The small grower, with the assistance of his family, usually does all the work required to prepare his onions for market, while the larger grower employs outside labor almost entirely.

Containers for Handling and Shipping.

To move onions in the field before screening, both bushel baskets and crates are used. The cost of the baskets is 50 cents apiece, and their life, with reasonable care, four years. Crates largely used for storage hold approximately 2 bushels, and cost from 25 to 30 cents apiece. Their life is from fifteen to twenty years.

For shipping purposes bags holding 100 pounds of onions are universally employed because they furnish protection and ventilation sufficient for short hauls. They are of convenient size for marketing and cheaper than crates. Several dealers have tried crates holding approximately a bushel of onions. These crates cost from 15 to 16 cents apiece, and much extra labor is necessary for filling and handling them. The trade was unwilling to pay for the additional expense and crates were given up.

Bags are usually furnished by the buyer. Three kinds are used by Connecticut Valley shippers, as follows: —

1. *Burlap or Cotton Meal Bags.* — The cost of these in 1915 was 8 cents, secondhand, 6 cents. Their use, however, is largely confined to the farm; that is, to the moving of onions from field to storage. On account of their close weave and unattractive appearance they are not suitable or practical for shipping onions intended for sale in the original package.

2. *Grass Sacks, originally Coffee Sacks.* — These are strong and, on account of their coarse mesh which allows the onions to show through, make a very attractive container. They also permit a rather free circulation of air, and make it possible for the prospective buyer to inspect the contents without opening the bag. The cost of these bags in 1915 was 10 to 11 cents apiece. This type of bag gives character to a shipment, and is very satisfactory both to wholesaler and retailer.

3. *Woven Paper Bags.* — While these have the same general characteristics as the grass bags they are cleaner looking and make a more attractive package. They are made in Buffalo and Cleveland, and cost 10 cents apiece. The only objection to them is their lack of strength when damp. A few bruised or rotten onions in contact with the bag frequently cause it to break.

Bags are never returned directly and are, therefore, a very real expense to the local dealer and to the farmer who ships his own onions. The secondhand bags which are used come back from retailer to ragman, to assembler, to jobber, to local dealer.

Methods of Sale.

A farmer either sells his onions directly from the field or holds them in storage for later sale. In either case, since comparatively few sales are made directly from producer to consumer, he is forced to market by making use of the present machinery for wholesale distribution.

The middlemen to or through whom growers can sell directly may be summarized as follows: local country buyers, local dealers and storage men, traveling buyers, brokers and commission men. They perform with more or less efficiency one or more of several necessary distributing services: (1) collecting, gathering or assembling lots of onions, (2) grading, sorting and bagging, (3) storing for later sale, (4) transporting for long or short distances, (5) making sales to other distributors or to consumers, and finding buyers and sellers, (6) financing either growers or distributors for short or long periods by credits or advances.

Local country buyers buy from the farmers in carload lots or assemble smaller lots, and ship to the best available markets, selling on orders or through the usual market channels for whatever margin they can secure. They pay cash at the shipping point at the time of sale or delivery, and often sell on ten to thirty days' credit. They usually buy for immediate resale, but if market conditions are not satisfactory they rent storage for a short period only. These country buyers are permanently located in the community and have reputations to uphold in order to obtain business. In addition to buying onions many of them also sell fertilizers.

Local Dealers and Storage Men.

These are easily the most important distributing specialists for Connecticut Valley onions; eight of them handle at present no less than 75 per cent. of the entire output of the valley. They differ from the so-called country buyer in that they are at the same time growers, dealers and storage men. Being residents of the community, they know and are known by the farmers. They pay taxes, initiate community projects and in every way share in the life and well-being of the community.

As a class, they generally stand back of their contracts, and are respected and admired for their businesslike methods of facilitating onion distribution. Whatever may be said of some individual dealers, it is quite certain that farmers have received better prices over a period of years because of the presence of these primary distributing agents. They follow the market, standardize the product and push the Connecticut Valley onion into all the principal markets of the Atlantic seaboard States. This class of middlemen clearly can perform a very real service to the growers; knowing the requirements and the needs of the market, their advice should help materially in producing more and better onions, in putting up for market a standardized, well-graded product, and in preparing an honest, attractive, uniform pack that will top the market and stimulate the demand for valley onions.

They have a good reputation with the commission men and wholesale dealers, most of whom prefer to buy from them rather than directly from the farmers. Unless the present system of distribution is radically reorganized efficiency in distributing Connecticut Valley onions will continue to rest very largely with this class of men.

Abuses by Local Dealers and Storage Men.

One charge made against dealers of this type is that they sometimes misrepresent the actual condition of the market in order to buy at better prices — they make the farmer a victim of sharp practice. Another is that they effect a combination in such a manner as to remove actual competition in buying from the growers. In other words, there is a feeling that prices are fixed by a few who gain a monopoly. This, of course, would result in the producer not getting his rightful share of a profit which the condition of the market warrants.

On the other hand, the dealers assert that some mutual agreement is necessary for self-protection against the more or less flagrant irregularities in grading and packing. However that may be, it is certain that consistent, honest practice on the part of the farmer would remove a part at least of the reasons for the alleged combination of dealers.

Still another charge is that when the crop is large, and the market rather unsteady, dealers often refuse to buy onions excepting at under-the-market prices and in small quantities, so that they are practically insured against loss. On the other hand, if the crop is short and the market steady, they are quite willing to buy freely because there is small risk. Certainly, they are in a position to know the market, and it is their duty as dealers to share their profits, or share with the farmer his risks or losses during a year of excessive production. Otherwise, the charge of selfishness is certainly well founded.

Fortunately, however, these practices are not common; many of them arise from misunderstandings, or the trouble may be traceable to the grower himself. The fact that the dealer knows the market and its demands, whereas the grower does not, causes the latter to be suspicious of anything which does not appear perfectly plain. Anything, therefore, which will give the grower a more definite knowledge of markets will do much toward bringing about a better feeling between him and the dealer.

Traveling Buyers and Brokers.

Traveling buyers and brokers operating in the valley work along lines similar to those of the local buyer. The broker buys in quantities desired and ships to wholesale houses which have placed orders with him. For his service he charges a definite brokerage, usually about $6 per car. In addition to buying on orders he also sells for growers and shippers. Carload lots are billed directly to him in the markets and, acting as the representative of the shippers, he effects sales subject to inspection merely upon identification of shipment.

The broker handles no funds, and his brokerage is fixed regardless of the selling price of the onions. He should prevent unwarranted rejections or secure proper allowances where rejection is justified. In practice, however, brokers frequently favor buyers in order to keep in good standing with the trade. They sometimes accept orders for more cars than the trade demands, simply to get the brokerage with resulting low prices to shippers. In late years their operations in the valley have hampered the storage men in getting the maximum price for their onions.

Traveling buyers are employed by individual wholesale or commission houses on a definite salary basis, and perform the services of brokers for these houses alone. The traveling buyer purchases from both growers and dealers, and thus by becoming an actual competitor of the local dealer increases the possibility of higher prices. When a short crop is reported in the commercial onion belt, a great many of these buyers flock to the Connecticut Valley. These men have less at stake than the

local dealer and are often less responsible financially. Sales should not be made to representatives of unknown firms until their business responsibility and the accredited standing of the representatives have been carefully investigated. In late years these traveling buyers have purchased largely through the local dealers, chiefly because they then have some guarantee that the onions will be fairly well graded; they are also protected against the possibility of losing onions made unfit by lax and faulty preparation for market.

Commission Men.

The commission men are dealers who receive shipments or consignments and remit the proceeds to the shipper after deducting a specified commission for selling, which for onions is usually 8 per cent. of the selling price. Some commission men, however, take 10 cents a bag commission; others ask $50 per car. In New York the rate of commission is usually less because of the larger market. Very few distributors of onions are commission men pure and simple. Ordinarily they combine the functions of jobbers and car-lot wholesalers with those of commission men. Three or four commission men in the Boston market specialize in Connecticut Valley onions.

In recent years there has been a decided falling off in the straight commission business, dealers and farmers preferring the more businesslike method of selling outright, either at the point of origin or at the destination. In cases where for any reason shipments are refused, commission men are frequently called into service.

Occasionally, agreements are made between the local dealer or shipper and a market representative, generally a commission man, for the purchase of onions on joint account. In such cases the latter contributes his knowledge of marketing conditions, and the former his knowledge of conditions at the producing end. Such agreements have been made frequently between certain large dealers in the valley and big commission firms in Boston. The division of expenses and profits varies greatly in different contracts, but the usual method is to divide net profits between shipper and market representative.

Sales for Immediate Shipment.

All onions from sets are sold from the field for immediate shipment. They are intended to supply the market after the Texas crop is gone and until the seed onions are harvested. When these appear, generally the latter part of August, sets should be entirely cleaned up.

A very large percentage of the seed onions of the valley is sold for immediate shipment. Such sales are made from the opening of the harvesting season until the first week in November. The exact quantity by weeks for three seasons is shown in the chart of shipments (Fig. 28). In nearly all cases the bags are furnished by the buyer.

The advantages of selling directly are obvious. The farmer gets

immediate returns for his crop, loses nothing by shrinkage and handles it only once. He assumes no risk of the keeping quality of the product and possible injury through extreme weather. He frequently gets pretty fair prices in the fall because of the competition among buyers, all of whom are desirous of securing their needful share. This is especially true when the crop is a short one either in the valley or the commercial onion-growing belt. At such times the grower often reaps the benefit of what may be termed a "fictitious local market," which is brought about by the speculators who boost the market higher than general market conditions warrant for the purpose of securing onions for storage in anticipation of a future profit which may or may not be realized. The dullest market usually comes in October after the first rush is over and the local dealers have secured the full quota for their storages.

Comparatively few onions are now consigned by small farmers directly to commission men. Sales made in this way are for the most part limited to transactions between growers who happen to know certain commission men and consign to them a portion of their own and occasionally a neighbor's crop. The reason for the decline in such sales is due, in large part, to the fact that the farmer prefers to sell for cash, to assume no risk in price fluctuations, and no quality or quantity losses; moreover, he prefers to sell to dealers with whom he can make terms in person.

The sales to local country buyers, traveling buyers, local dealers and commission men for immediate shipment vary considerably from season to season, depending upon the strength of the market and the size of the crop. In 1913 the shipments to November 4 amounted to 1,423 cars, or approximately 50 per cent. of the total shipments for the season. In 1914 the shipments to the same date were 2,277 cars, constituting about 60 per cent. of the total shipments for the season. In 1915 the shipments were 1,730 cars, or 52 per cent. of the crop.

An analysis of the total shipments for the season 1913–14 at one of the leading shipping points shows the following facts: —

Total number of cars shipped,	1,122
Cars shipped by 4 local dealers,	947
Cars shipped by all the local buyers and dealers,	1,077
Cars shipped by farmers interested only in marketing their own product,	49
Cars shipped by Boston dealers,	6

A similar analysis of the shipments for the season of 1914–15 at the same station shows that up to November 1, 4 local dealers shipped 477 cars; all dealers and buyers shipped 624 cars; and farmers shipped 75 cars.

From November 1, 1914, to the end of the season, practically all storage onions, 4 dealers shipped 541 cars; all dealers and buyers shipped 663 cars; and farmers shipped 57 cars.

Sales from Field to Local Storage.

A great many of the onions purchased in the field by local dealers are put into storage. Such sales are usually consummated early, often before the onions are out of the ground. Onions for storage are selected on the basis of size, general appearance and keeping quality, and it is not uncommon for the storage men to stipulate the conditions of harvesting, curing and delivery of such onions. If, on delivery, the onions are not all up to the standard required, the poorer are screened out and marketed immediately and the rest stored. Onions that will store well always sell readily, frequently at a special price.

The quantity stored naturally varies from year to year, according to the crop and the conditions of the market. The local dealers who store are almost without exception also growers; hence, they may store a large portion of their own onions, and consequently buy fewer from other growers for this purpose. They may sell their own directly and store those purchased from others. In 1914–15, of the 673,900 bushels held in local and terminal storages, approximately 300,000 bushels were purchased from the growers for storing; of the remainder, 111,200 bushels were raised by the storage men themselves; the remaining 276,400 bushels were taken care of by hiring storage space either in the valley or at Boston.

Sales after Storage.

1. *By the Farmer.* — The onions stored by the farmer for later sale may be held (*a*) in temporary storages (tobacco shed, barns or cellars); (*b*) in his own private warehouse; (*c*) in a commercial storage where he rents space at a fixed price per bag or crate.

If held in temporary storages, onions are sold usually before Thanksgiving Day; if held in a private warehouse or commercial storage they are sometimes shipped by the grower himself at periods when market conditions appear most favorable. Many of the farmers' holdings in commercial storages are sold directly to or through the owner of the storage or some other local dealer.

The quantity of onions thus held varies greatly from year to year. If the season is a short one buyers are anxious and prices are high. Such conditions usually induce the farmer to sell and thus escape storage charges and probable loss by shrinkage. On the other hand, when the acreage is large and the yield heavy, prices are usually unsatisfactory and buyers hold off. At such times, farmers store for later sale and better prices.

2. *By Dealers.* — Storage men do not as a rule begin to ship before the first of December. In 1915–16 the number of bushels shipped from the first of December to the end of the season was approximately 670,000; in 1914–15, 585,000 bushels; and in 1913–14, 582,000 bushels. Practically 90 per cent. of these were shipped by local storage men and dealers. These shipments go to commission men, jobbers, wholesale distributors and retailers in practically all of the principal markets of the Atlantic States

and Canada. A few are consigned to Havana, and some years a large quantity is exported.[1]

The general problem of the local dealer in the distribution of onions may be stated thus: to keep in touch with general market conditions in all of the principal markets; to buy intelligently; to ship as the market demands; and to keep up the standard of his product without heavy losses from shrinkage. In short, he must know onions, onion growers, current market conditions, transportation and storage requirements, the needs of the market, and the marketing machinery available for wholesale distribution.

Storage of Onions.

Methods of Storage.

Onions are stored by farmers either in temporary or permanent storages. Temporary storages are barns, tobacco sheds or cellars. By covering the onions with hay or fodder they can easily be kept until Thanksgiving. After this date very few onions remain in temporary storages.

Only twelve permanent farm storages were found in the course of this investigation. Their total capacity is approximately 35,000 bushels, and in practically every instance the owners found it necessary to buy additional onions to fill them. Such men are in a sense local dealers or speculators. In 1914 the total quantity held in both temporary and permanent farm storages was about 250,000 bushels.

The cut below shows an excellent type of storage for the farm. This building follows refrigerator construction throughout, having three 4-inch dead-air spaces in the side walls. The ventilators are easily worked, and the storage is thus kept cool and dry. The shrinkage record of this particular storage is very low, and onions have been held in it from October until the end of April.

The capacity is 5,000 bushels, and the cost including equipment is approximately $1,400. The overhead charges are about four cents per bushel, distributed as follows: —

Interest on investment, $1,400 at 5 per cent.,	$70 00
Insurance at $1.25 per $100,	17 50
Taxes, $700 at $18 per $1,000,	12 60
Repairs, 1 per cent.,	14 00
Depreciation, 4 per cent.,	56 00
Care, etc.,	5 00
Insurance on onions at 40 cents per bushel at $1.25 per $100,	25 00
	$200 10
Cost per bushel (5,000 bushels capacity) approximately,	04

The cost of removing from storage is about 2.5 cents per bushel, making the entire cost of storage 6.5 cents per bushel. This includes no allowance for shrinkage, which in the particular storage is said to average not more than 2 per cent., or approximately 100 bushels for the season.

[1] For the primary destination of onion shipments from the valley, see table of primary distributing points for Connecticut Valley onions, p. 103.

Hired Storage.

A number of the growers, as well as some of the dealers, who do not own their storages, rent space in the various commercial storages of the valley for a portion of their product. In 1914–15 the quantity so held exceeded 250,000 bushels. When the crop is heavy and fall prices are low the demand for space in these commercial storages is very great.

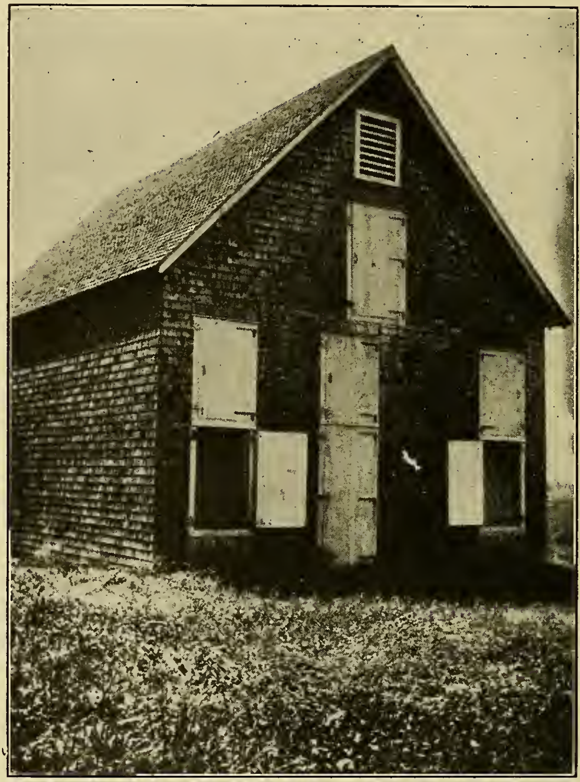


FIG. 18. — A good type of farm storage. The ventilators are well placed. Such storages yield good returns and should be found in greater number throughout the valley. The storage faces east.

If space only is rented, in which case the farmer does all the work of storing, the rate for the season is 14 cents per bag or crate. The more general method, however, is for the owner of the storage to do all the work after the onions have been delivered at the warehouse. This includes rescreening, bagging and loading on cars for final shipment. The rates charged under this form of rental are as follows: —

For less than 5 carloads,	25 cents per 100 pounds
For 5 to 10 carloads,	24 cents per 100 pounds
For 10 carloads up,	23 cents per 100 pounds

At these rates the grower simply delivers to the storage and, as noted above, all subsequent charges including insurance are borne by the storage man.

Onions are put into storage during September and October, and are generally sold before March; indeed, in order to avoid excessive loss by shrinkage, a good many are sold before Christmas.

Hired storage holdings may be shipped directly by the growers, but very frequently they are sold to or through the local dealer. When a dealer buys onions out of storage he pays for the number of bushels they will screen, which means, of course, that the grower has to bear the loss due to shrinkage. On the other hand, the storage charges are figured on the basis of the number of bushels delivered to the storage, and no account is taken of the length of the storage period.

Storage by Local Corporations or Dealers.

There are about thirty storages in the Connecticut Valley; including two built in 1915, they have a total capacity of approximately 600,000 bushels. They are fairly well distributed throughout the valley, as shown by the accompanying map. With the exception of Whately, each town has at least three storages. In 1915 the number of commercial and private storages, together with their joint capacity in each town, was as follows: —

Town.	Storages.	Commercial.	Farm.	Capacity (Bushels).
Amherst,	3	1	2	32,400
Hadley,	5	4	1	119,500
Deerfield,	8	4	4	139,000
Hatfield,	4	3	1	158,500
Sunderland,	12	8	4	142,000
Totals,	32	20	12	591,400

With the exception of a few storages owned by local storage corporations all the warehouses are located on farms some distance from the railroad. In the case of the principal storages, however, this distance does not exceed 2¼ miles.

Storage Men.

With the growth of the onion industry in the Connecticut Valley the storage men developed in a very natural way. At first they were large growers who held their onions for better prices. Very soon, however, they also bought the product of others and held it. With larger quantities in their possession and a better knowledge of markets and marketing machinery, speculation and storing became their regular business.

Even to-day there are few exclusively storage men; they are at the same time growers and dealers. They raise onions on their own farms, buy

from other farmers for immediate resale, and store such portion of their own onions and purchases as general market conditions may warrant.

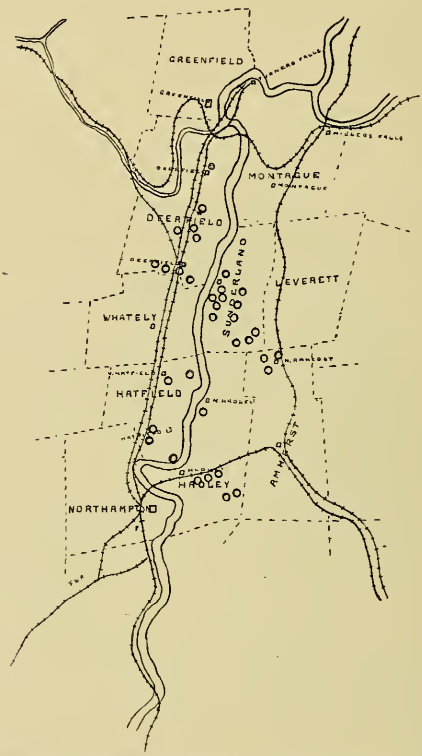


Fig. 19. — Map showing the location of the principal onion storage houses of the Connecticut Valley in 1915.

The owners of the various storages and the managers of local storage corporations are men well known in the valley, and farmers both large and small sell to them directly.

Description of Storage Equipment.

The storages are equipped with crates or bins, or both. In a few warehouses bags are still used for storing.

1. *Crates.* — The slatted crate is used almost exclusively for the storage of onions. It holds approximately 2 bushels, and permits of free circulation of air. Well-made crates now cost 25 to 30 cents apiece, and with average care last at least fifteen years. In the storage the first tier of crates is placed on "two-by-fours" to allow the air to circulate under them. Crates are scantily filled, so that when stacked one on top of another,

there is at least an inch of air space between the onions in one crate and the bottom of the crate above.

To facilitate handling there is a central alley running lengthwise through the building. A derrick for lifting the crates is operated in this alley. Cross alleys running from one pair of ventilators to the opposite pair provide for the free circulation of air.

Fig. 20. — Onion topping machine. This machine is now used by six or seven of the leading onion growers in the valley. Its capacity is from 600 to 1,000 bushels per day. The elevator which carries the topped onions into the bags is lowered to a horizontal position when the machine is at work.

2. *Bins.* — Bins for storage are usually 8 feet wide and 15 feet deep, having portable shelves which slide into position on supports at each side. On this shelving onions are placed from 6 to 8 inches deep, allowing a 2-inch space for air circulation above each shelf. This is the cheapest method of storing as far as labor is concerned, and the up-keep is also small. Considerable attention, however, must be paid to the upper tier of bins, because the heat seems to affect onions stored in this way more than those stored in crates. They grow and rot much more quickly.

In order to avoid excessive loss, it frequently becomes necessary to market the onions in the upper bins very early in the season. A few storages are equipped with bins holding from 50 to 80 bushels, and having a depth of about 18 inches.

3. *Bags or Sacks.* — Formerly a great many onions were stored in bags. A few storage men in the valley still use them, placing the bags two or three deep on shelves, thereby saving much time and labor of extra handling. In years when onions are not of the best quality and the outside skin comes off easily bags are very satisfactory. As a rule, however, dealers agree that the shrinkage is greater, and that onions so stored discolor the bag and make it unsuitable for shipping. Some onions, especially those intended for early shipment, are stored in this way in practically every storage.

Dates and Periods of Storage.

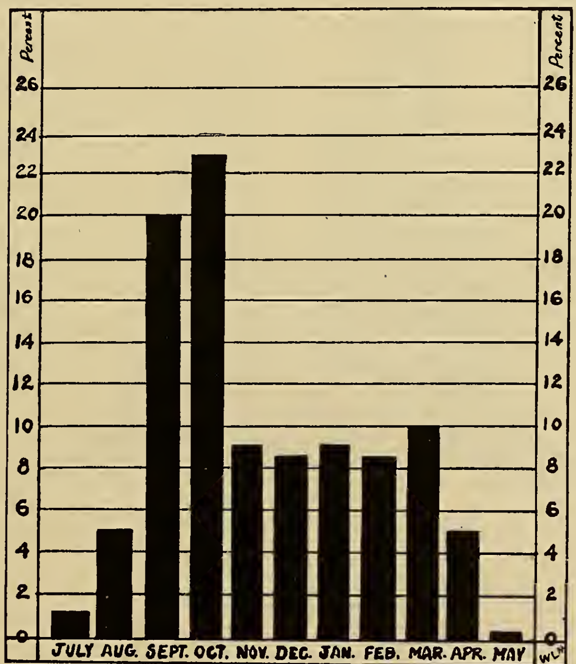
The major portion of the storage onions are placed in storage during the month of October. By the end of November shipments from field and from temporary storehouses have ceased, transactions thereafter being entirely with storage onions. For two months loss by shrinkage is comparatively small and accordingly shipments are light. In December storage onions begin to move and by the end of March practically all are marketed. These periods vary somewhat from year to year with the keeping quality of the crop and the market price but, as a general rule, as soon as there is danger of loss from shrinkage or other cause the storage men begin to unload. It will be noted from the accompanying diagram that a little over two-thirds (68.5 per cent.) of the 1914 crop was marketed directly from the field or temporary storage from July to December. One-third (31.5 per cent.) of the crop was put into permanent storage. The shipments for December constituted only 3 per cent. of the crop, but during January, February and March 25 per cent. of the total crop was marketed. On March 31 only 3.5 per cent. remained in local storages. Some years when the demand is strong and the quality of the onions good a considerable quantity is removed to cold storage about March 1.

March is the period of greatest activity. In the 1913–14 season, considering merely that portion of the crop stored, 26.6 per cent. of the onions were moved out during March; 21.2 per cent. in February; 21.9 per cent. in January. In other words, practically 70 per cent. of the storage onions were shipped to market during those three months. In the season of 1914–15 nearly 80 per cent. of the crop stored was marketed during the same period. March was again the month of heaviest shipment with 35.4 per cent.; February with 25.4 per cent.; and January with 18.9 per cent. of the stored onions.

Of the 1915 crop 59.7 per cent. was shipped from July to December. The shipments out of storage by months follows: —

MONTH.	Number of Cars.	Percentage of Entire Crop.
December,	272	8.1
January,	245	7.3
February,	255	7.6
March,	466	14.0
April,	107	3.2
May,	3	.1

Taking the 40.3 per cent. held in storage, 34.7 per cent. of them were shipped in March, 18.8 per cent. in February and 18.1 per cent. in January.



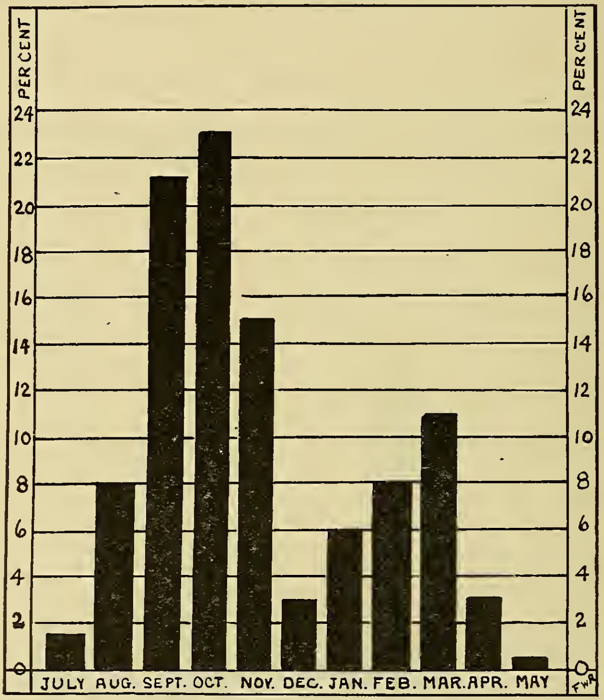
CONNECTICUT VALLEY ONION SHIPMENTS

FROM LOCAL POINTS 1913-14.

FIG. 21. — Note the uniformity of the shipments from November to April.

The maximum length of time onions are held in local storage is eight months; the minimum about one month; while the average period of storage is approximately three months.

The monthly shipments out of storage during 1913–14 show a remarkable uniformity. This was due in part to the short season and the fact that practically all storage holdings were in the hands of local dealers. It was a good year for them. The market was steady and the demand constant. The shipments from the valley were equally constant and helped very materially to maintain a firm market.



CONNECTICUT VALLEY ONION SHIPMENTS FROM LOCAL POINTS 1914-15.

FIG. 22. — Compare this with Figs. 21 and 23, and note how an unsteady market affects shipments.

The 1914–15 season, on the other hand, shows the effect of a wavering and uncertain market. The unusually heavy shipping to the end of November, due to good prices for "sets" and early fall onions sold from the field, broke down the market so completely that it continued unsteady until the end of the shipping season. In fact, its unsteadiness, aggravated by an abundant Texas crop, so affected the market for "sets" during the 1915–16 season that many were sold below the actual cost of production.

The shipments for the 1915–16 season show the peculiarities due to a good season from the standpoint of price. Early harvesting was delayed

by numerous rains and lack of sunshine. Besides, the activity of the buyers and the reports of the Ohio and Indiana floods gave some farmers courage to hold the crop. This explains in part the unusually light shipment for September, and the correspondingly heavy shipment for October. The diseased condition of many crops, which made the onions undesirable for storage, was another reason for the heavy shipments during October.

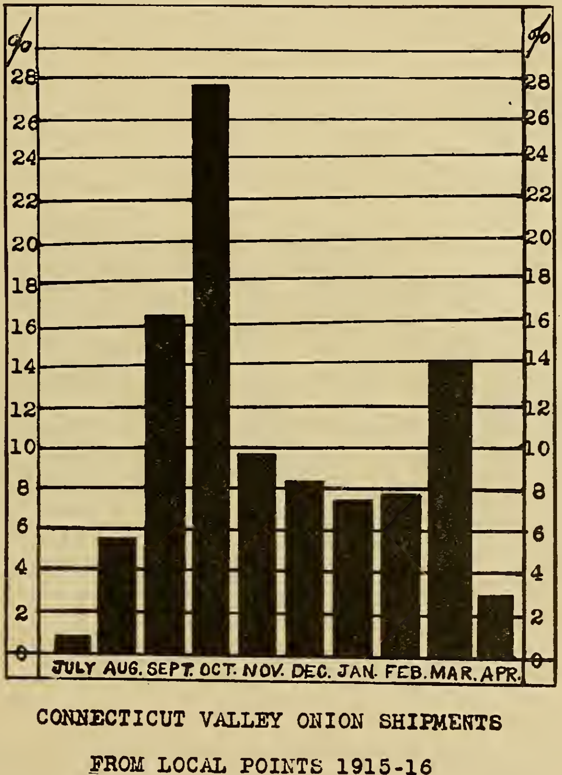


FIG. 23. — Note the exceptionally large quantity shipped in March. Onions were held as long as possible for higher prices, but had to be shipped in March (1) to prevent excessive loss through shrinkage, and (2) to escape competition with the Texas crop reported to be unusually large and early.

The shipments during November, December, January and February show a marked uniformity similar to that of the 1913–14 shipments. The heavy shipping in March was occasioned by the fact that onions were not keeping and the market was good. Besides, there were reports of an unusually heavy and early Texas crop. As a result, barely 3 per cent. of the crop remained in the local storages after April 1.

Cost of Local Storage.

The usual items in the cost of storage have been considered, but since rates and methods of insurance and taxation differ in various sections, a brief explanation of the figures used in our computation seems advisable. The valuations of storages and equipments were furnished by their owners. Five per cent. of the valuation was allowed for interest. The tax rate varied in 1915 from $16.50 to $20 per $1,000; hence, the flat rate of $17 per $1,000 was used. There seems to be no uniform principle upon which

FIG. 24. — The first onion storage built west of the Connecticut River, at South Deerfield. This storage is still used. The pile of rotten onions on the left is an illustration of loss through shrinkage.

storages and equipment are assessed for taxation, but in every instance studied the assessment never exceeded 65 per cent. of the actual value as given by the owners; hence, this maximum ratio was used as the basis of taxation.

Insurance.

The rate of insurance on buildings varies according to the location of the building and the material of which it is built. The usual rate, however, is $1.25 per $100 per year. The total valuation of storages and equipment was given as $211,000; therefore, $200,000 seemed a generous estimate of the insurance carried.

Few reliable figures could be secured upon onion insurance. A good many of the onions are not insured, while others are insured only at a certain percentage of their actual value. In view of this difference in

practice among storage men and in rebates allowed because of short-term insurance, the onions (486,900 bushels) were figured at 30 cents a bushel, and the rate of insurance taken at $6 per $1,000 per year.

Depreciation.

Four and one-half per cent. is a fair allowance for depreciation and repairs. It was arrived at in this way. The ratio of the value of the storage to its equipment is approximately 3:1, but the life of the building is about forty years, while that of equipment, especially crates, is possibly only fifteen years; hence, depreciation for crates is 6.6 per cent., and for storage 2.5 per cent. Taking three times the building depreciation, plus once the equipment depreciation, and dividing by four we have 3.5 per cent. — the depreciation of buildings and equipment. For repairs 1 per cent. was allowed.

In accordance with the above principles the distribution of the overhead charges for storage of onions is as follows: —

Number of storages considered,	22
Capacity (bushels),	486,900
Total valuation, including equipment (crates, bins, derricks, etc.),	$211,000 00
Interest on investment at 5 per cent.,	$10,550 00
Taxes, $17 per $1,000 on 65 per cent. of valuation,	2,331 55
Insurance on buildings and equipment ($1.25 per $100 on $200,000),	2,500 00
Insurance on onions (486,900 bushels at 30 cents) $6 per $1,000,	876 42
Depreciation at $3\frac{1}{2}$ per cent.,	7,385 00
Repairs, 1 per cent.,	2,110 00
Total overhead charges,	$25,752 97
Overhead charges per bushel,	$0 053

In all these computations rather high valuations were made, so that $0.053 per bushel seems a generous allowance for overhead charges.

Specific Problems of Storage.

The first problem of the storage man is to secure a sufficient quantity of good storable onions. He solves this by purchasing early, especially when the crop is reported short. In many cases contracts between grower and dealer are made even before the onions are harvested.

His second problem is to reduce shrinkage to a minimum. Shrinkage is dependent upon the quality of the onions, the temperature changes of the season and artificial atmospheric regulation of the storage. Over the first two factors the storage man has practically no control except in so far as he may select storable onions and ship immediately all other purchases; but some years even the most carefully selected stock keeps

poorly. This was notably true of the product stored in 1915–16. The temperature of the storage should be kept as near 30° F. as possible by using the ventilators.

The problem of timing shipments to conform to the rise and fall of the market necessitates an acquaintance with the condition of the onions in storage, transportation facilities and methods, and onion market conditions in all the principal cities.

The selection of safe and reliable men at the receiving end is another problem. This is necessary, for even honest business men are strongly tempted to refuse consignments if the market is on the decline when they arrive. This is one of the chief reasons why the small farmer cannot risk direct shipment.

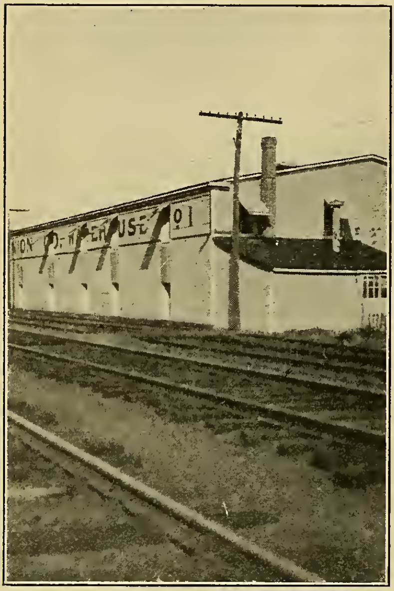


FIG. 25. — A newer type of onion warehouse. Note the number and arrangement of the ventilators. A portion of a roof ventilator is shown to the right of the brick chimney.

Still another problem is to keep down the cost of doing business; that is, office expense, up-keep of storage, purchase of bags and labor expense. In a large way these costs per bushel seem to vary immediately with the quantity stored provided the storages are filled to capacity.

Shrinkage.

The data collected from twenty-two storages show that the shrinkage for the season of 1914–15 was about 10 per cent. of the quantity stored. It is seldom less than 7 per cent. for any one year, and hardly ever exceeds 15 per cent., except for onions held until the very last of the season. The crop of 1915 was unusual in this respect. The wet season of 1915 caused the onions to become affected with "slippery skin" and "center rot," so that losses as high as 35 per cent. were reported. The average shrinkage, however, probably did not exceed 20 per cent.

Shrinkage losses as well as the cost of extra handling must be considered in computing the total cost of storage. In figuring the shrinkage loss, the value of the onions stored is taken at $1.14 per 100 pounds, which represents the average price paid to farmers for the three years, 1913–15.

The cost of extra handling from storage and loss by shrinkage on the basis of 250 bags would be as follows: —

To regrade and sack, 5 men 1 day at $1.75,	$8 75
To load and unload, 1 man 2 hours at 17½ cents,	35
To haul to station, man and team 1 day,	5 00
Shrinkage, 25 bags at $1.14,	28 50
Total cost, shrinkage and handling,	$42 60
Total cost per bushel (450 bushels),	$0 095
Cost per bushel *not including shrinkage*,	031

It is to be noted, however, that the item for regrading and sacking is considerably higher during a season when onions keep poorly.

The 9.5 cents is the cost of removing from storages located at some distance from the railroad. For storages from which onions may be loaded into the car directly this cost is about 8⅛ cents per bushel. Summarizing these costs, we have —

	Including Shrinkage.	Not Including Shrinkage.
Overhead charges per bushel (page 93),	$0 053	$0 053
Removal from storage and shrinkage,	095	031
Total, per bushel,	$0 148	$0 084

We have previously shown that the usual charge for storage in commercial warehouses is 23 to 25 cents per bag of 2 bushels, not including shrinkage. This contrasts with an actual average cost of 17 cents per bag. This cost may be still further reduced if the farmer does the work himself at a time when he has little or no other work.

Immediate Sale or Storage.

In the light of the above costs and the experiences of storage men in the valley should a farmer sell directly from the field or store? The question is one of relative profitableness, the chief reason for holding being the hope of selling at a higher price. It is readily seen that prices received must be high enough to pay interest on the amount for which the onions might have been sold in the fall, to cover loss by shrinkage and to pay for storing and the extra cost of handling. The cost of these, with the exception of the item for interest, is 14.8 cents per bushel, or approximately 29.5 cents per bag.

The four-year (1911–15) average monthly wholesale price per 100 pounds on the Boston market as given in the Quincy Market Bulletin was as follows: —

September,	$1 62	January,	$1 94
October,	1 52	February,	2 34
November,	1 72	March,	2 45
December,	1 70	April,	2 46

While these prices are somewhat higher than the grower received, the farmers' prices for the same months would show about the same variation. The table shows that the average March price is about 52 per cent. higher than the September price.

We are now able to estimate the farmer's possible gain by holding his crop. The table above shows a steady rise in price from December to April. The question is whether this rise is sufficient to cover the items of extra expense before enumerated.

As an illustration, let us take the case of a farmer who has 1,000 bags of onions. By selling in September at the price listed he would receive $1,620. The interest on this at 5 per cent. for five months would be $33.75, or 3.4 cents a bag. Adding to this the loss from shrinkage, overhead charges for storage and extra handling, we have a total cost of 33 cents a bag. The average price during the storage months is $2.18 per bag. This is 56 cents above the September price, 66 cents above the October price, and 46 cents above the November price. According to these figures it would pay this farmer to store.

The general plan, however, is for the small grower to rent storage space at 25 cents a bag. Add this to the increase for shrinkage, 11.4 cents, and interest, 3.4 cents, and we have a total advance of 39.8 cents per bag. Even under this plan the farmer who stored would gain over his neighbor who sold in September and October; moreover, it appears that the charge of 25 cents per 100 pounds is higher than necessary for the commercial storage of onions. Of course, the man who holds his crops for any particular season must take chances on shrinkage and on receiving the average price indicated.

Local Cold Storage.

No onions are placed in cold storage in the valley, though one of the storages is so constructed that a cold-storage plant may be installed at any time. Local warehouses are used almost exclusively until March, and after that date some onions are put into cold storage in Boston and New York where they are kept as late as the first of May.

In the opinion of a number of leading growers and storage men, a cold-storage plant in the valley would be a profitable investment. Others argue that since the Connecticut Valley onions must be closed out as soon as possible after the middle of April because of the arrival of the Texas Bermudas, the period would be too short for the profitable operation of the expensive equipment necessary; moreover, the shrinkage of onions in cold storage is usually high. In spite of every precaution the onions seem to absorb moisture which greatly impairs their keeping quality.

Terminal Storages.

Terminal storages are of two kinds: —

1. *Common.* — Of the large quantities of onions shipped to the principal markets during the months from September to December, a great many are held in lofts, cheap warehouses and potato warehouses for later sale.

While the quantity so held varies with the season it is usually large in November and December, especially during years when the supply in the valley is large and the market rules firm. The charge per month for ordinary common storage is about 6 cents per bag.

2. *Cold Storage.* — The principal cold storage for Connecticut Valley onions is the Quincy Cold Storage and Warehouse Company in Boston. It is located on the Union Freight Railway, connecting with all railroads entering Boston. It has a capacity sufficiently large to take care of any quantity which dealers may send. Very few onions are put into this storage before March. In 1915 the quantity by months held by this storage was as follows: —

	Bags.
March,	27,744
April,	4,005
May,	3,000

The charge for terminal cold storage in less than carload lots is 15 cents per bag the first month and 12.5 cents per month thereafter; in carload lots 12 cents per bag per month; if stored in barrels the charge is 20 cents per barrel for the first month, 15 cents for the second, 10 cents for the third and 5 cents for the fourth, making a total of 50 cents per barrel for the maximum period stored.

Terminal storage is of great importance in onion distribution. Shipments cannot always be properly gauged as to time and quantity. By holding excessive shipments in terminal storages and releasing them when shipments do not meet the demands of the trade the market may be steadied to a considerable degree.

Transportation of Onions.

Local Transportation.

Onions sold for immediate shipment are bagged in the field and hauled to the local shipping point on an ordinary farm wagon with a low bed. While the length of wagon haul varies, the average, as previously stated, does not exceed $2\frac{1}{2}$ miles. The main roads in the district are excellent, especially those leading from Sunderland to South Deerfield and from North Amherst to Amherst over which thousands of bushels are moved. These roads have only a few steep grades, and two horses can easily haul a load of 60 to 65 bags.

The branch roads are generally sandy and unimproved, which makes hauling difficult and increases the cost accordingly. The average cost of local transportation from field to local storage or shipping point is approximately 1 cent per bushel. Storage warehouses are either on the railroad or within an average distance of $2\frac{1}{2}$ miles. If on the railroad, the onions are put into cars directly from the warehouse. Those at some distance are sufficiently near to enable a team to make at least four trips a day. The cost of such transportation is discussed under "Storage" (page 95).

Transportation from Local Shipping Points.

Transportation routes and the distances between the local shipping points in the Connecticut Valley onion district and Boston and New York are shown on the map below.

FIG. 26.

Trolley Transportation.

The Amherst and Sunderland Street Railway running on the east side of the Connecticut River between Amherst and Sunderland is the only trolley line in the valley which has a franchise and equipment for handling freight cars. At Amherst this electric line connects with the Boston & Maine Railroad, running between Northampton and Boston. This trolley freight service is used by the storage men and a number of the large growers in the vicinity of North Amherst. It is a great convenience in the autumn when the farmer is pressed for time, and for late winter shipments it is almost a necessity on account of the danger of freezing while in transit by wagon. Until December ordinary box cars are used, but thereafter refrigerator cars are used almost exclusively.

Until Sept. 1, 1914, the rate per carload to Amherst was $6 from Sunderland and $5 from North Amherst. Since then the charges have been increased to $10 from Sunderland and $8 from North Amherst. These charges are considered too high, and a good many of the shippers are now hauling onions directly to the railroad stations at Amherst, Cushman, Hadley and South Deerfield. In spite of the heavy crop harvested during the season 1914–15 the shipments by trolley showed a decided falling off.

The trolley shipments by months from 1913 to 1916 were as follows: —

Month.	1913-14.	1914-15.	1915-16.
	Cars.	Cars.	Cars.
August,	2	–	1
September,	10	2	9
October,	19	24	13
November,	5	9	–
December,	6	2	2
January,	9	7	9
February,	11	11	12
March,	16	18	18
April,	7	1	8
Total,	85	74	72

Railway Transportation.

Three lines of railroads serve the Connecticut Valley growers — the Boston & Maine, the New York, New Haven & Hartford, and the Central Vermont. The principal shipping points in the valley, together with the number of cars shipped from each point during the three seasons of 1913, 1914 and 1915, are given below: —

Station.	Boston & Maine Railroad.			New York, New Haven & Hartford and Central Vermont railroads.		
	1913-14.	1914-15.	1915-16.	1913-14.	1914-15.	1915-16.
Amherst,	163	230	153[1]	4[2]	8[2]	7[2]
Deerfield,	36	61	38	–	–	–
Greenfield,	–	15	14	–	–	–
Hadley,	305	476	433	–	–	–
Hatfield,	460	575	429	–	–	–
Montague,	24	43	39	–	–	–
Montague City,	–	1	–	–	–	–
Northampton,	49	57	55	–	–	–
North Hatfield,	462	577	445	–	–	–
South Deerfield,	1,189	1,424	1,462	47[3]	84[3]	51[3]
Whately,	217	262	210	–	–	–
Cushman,	–	–	–	–	13[2]	4[2]
	2,905	3,721	3,278	51	105	62
	51	105	62	–	–	–
Totals,	2,956	3,826	3,340	–	–	–

[1] In 1915-16 a considerable number of cars of onions produced in Amherst were shipped by way of Sunderland and Hadley, which explains the apparent drop from 163 cars in 1913–14, to 153 cars in 1915-16.

[2] Central Vermont.

[3] New York, New Haven & Hartford.

The shipping season begins about the middle of July and ends the latter part of April or the beginning of May. The accompanying chart gives the shipments by weeks for the seasons of 1913–14, 1914–15 and 1915–16. Very few shipments suffer any marked loss in transit. As a rule, onions that arrive in poor shape at their destination were questionable when

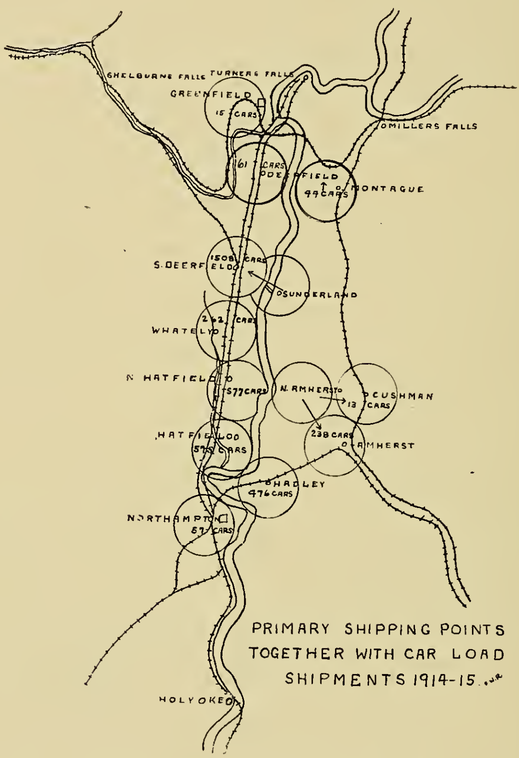


FIG. 27. — The shipping points of the Connecticut Valley. This map shows the relative importance of the various districts as onion-producing centers by the number of cars shipped from each station during the 1914–15 season. South Deerfield, from which point all the Sunderland onions are shipped, is by far the most important shipping point in the valley.

consigned. Occasionally, however, they suffer through extremes of heat or cold. Most of these complaints come during the early fall and the late spring.

Methods of Shipping.

Practically all shipments are made in 100-pound bags. Occasionally a car is loaded in bulk, but this method of shipping is not considered advisable, because the onions are likely to heat especially during Septem-

ber and October when the weather is warm and the onions are not yet well cured. Until December ordinary freight cars are used, but after that date refrigerator cars are used almost exclusively. These are frequently

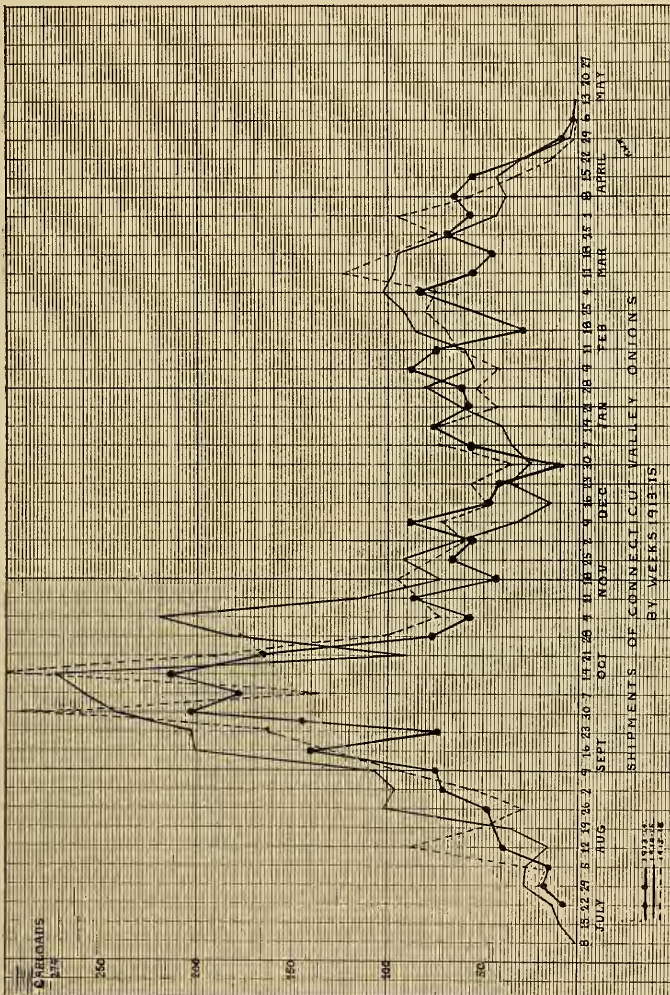


FIG. 28. — Note the exceptionally heavy shipments during the last two weeks in September and the first three weeks in October, the light shipment during Christmas week and the heavy shipments in March.

lined with heavy paper to keep out the cold. In extreme weather the cars may be heated with oil stoves.

The average carload contains 250 bags, approximately 500 bushels. The freight rates per 100 pounds in carload lots from different shipping points in the valley to some of the principal markets are as follows: —

	Cents.
Amherst to Boston, Central Vermont Railroad,	11
Cushman to Boston, Central Vermont Railroad,	14
Cushman to Norwich, Ct., Central Vermont Railroad,	13
Cushman to Stafford, Ct., Central Vermont Railroad,	12
Greenfield to Boston, Boston & Maine Railroad,	12
South Deerfield to Tampa, Fla., Boston & Maine Railroad,	42
Amherst to Boston, Boston & Maine Railroad,	12
Amherst to New York, Boston & Maine Railroad,	17
Hadley to Boston, Boston & Maine Railroad,	12
South Deerfield to Boston, Boston & Maine Railroad,	13
South Deerfield to New York, Boston & Maine Railroad,	13

Problems of Transportation.

Shortage of Cars.

When shipping is at its height some trouble is experienced in getting a sufficient number of cars. This is not always due to a real shortage of cars, but rather to a lack of extra track for the placing of empty cars at some of the local shipping points in the valley. In general, however, there is little complaint against the railroad companies in this respect.

Fig. 29. — Loading onions into the car. Note the coarse mesh bag and the typical method of handling it. After December 1 refrigerator cars are used almost exclusively.

More frequent complaint comes because of delays while in transit. Onions which leave the valley on Thursday should arrive at Boston the next morning in time for the Friday morning market. Shipments which do not arrive at that time must be held over until the following week, because Saturday's market is usually small. During the fall such delays are especially frequent making it difficult to time shipments properly.

Demurrage.

Demurrage in Massachusetts is regulated by a commission which has accepted without any prescribed regulations the application of the "unified code" or "national car demurrage rules" by the railroad companies. Among other things this code allows forty-eight hours for loading and unloading cars, such time to be computed from the first 7 A.M. after placement and notice. Sundays and holidays are excluded in the computation of time. The charge is $1 per day or fraction thereof after the expiration of "free time" until cars are released. It also makes provision for an extension of time when it is impossible to load or unload on account of

weather conditions, or when serious injury would result to the freight from loading or unloading under adverse conditions.

The New England Demurrage Commission, with headquarters at Boston, was established in 1910. All the lines in New England are members of it, and, while each line publishes and files its own demurrage tariff, a demurrage commissioner has general oversight of all demurrage matters. He is "to arbitrate all doubtful or disputed cases growing out of the application of the demurrage rules which the shippers or the roads desire to refer to him." As an impartial investigator and referee he attempts to secure from the railroads their best possible service, and from shippers co-operation by the prompt release of cars in order that commerce may be facilitated and that efficiency of transportation may be increased. Cases of demurrage charges against Connecticut Valley shippers are comparatively few.

There are certain dealers, however, who use cars for storage purposes at local shipping points. One dollar a day is not a heavy charge for keeping onions protected from the weather and ready to rush to market at the most opportune time. This is not a common practice, however, being limited largely to buyers who have no storage of their own, and to the late autumn in seasons when the market rules firm.

Prices of Onions.

Supply and Demand.

Statistics secured from the various transportation agencies for the shipping seasons 1913–15 show that the primary markets for Connecticut Valley onions are the principal cities of the New England and Middle Atlantic States. A considerable number are also finding their way into the markets of Canada and the South Atlantic States, and recently smaller shipments have even been made to the Philippines, Cuba and Europe.

The principal cities, with the number of cars of onions shipped to each during the seasons of 1913–14 and 1914–15, were as follows: —

City.	Number of Cars, 1913-14.	Number of Cars, 1914-15.
Maine.		
Auburn,	5	11
Bangor,	24	39
Portland,	81	96
Rockland,	2	11
Total Maine markets,	147	212
New Hampshire.		
Keene,	22	12
Manchester,	14	34
Nashua,	6	11
Total New Hampshire markets,	66	99

City.	Number of Cars, 1913-14.	Number of Cars, 1914-15.
Vermont.		
Norwich,	11	16
Rutland,	4	8
Total Vermont markets,	31	47
Massachusetts.		
Boston,	707	983
Brockton,	10	27
Greenfield,	14	35
Haverhill,	7	21
Holyoke,	26	13
Lawrence,	22	47
Lowell,	27	38
Lynn,	20	18
New Bedford,	30	34
North Adams,	14	21
Northampton,	43	35
Pittsfield,	14	18
Salem,	10	13
Springfield,	71	70
Worcester,	59	104
Total Massachusetts markets,	1,173	1,589
Connecticut.		
Bridgeport,	27	38
Hartford,	57	60
New Britain,	10	21
New Haven,	70	84
New London,	5	12
Waterbury,	30	41
Total Connecticut markets,	233	287
Rhode Island.		
Providence,	189	248
Total Rhode Island markets,	196	258
New York.		
Albany,	36	22
Barclay Street,	206	195
Brooklyn,	22	12
Buffalo,	14	2
Harlem River,	107	196
New York City,	38	85
Schenectady,	16	17
Troy,	26	26
Total New York markets,	479	571

City.	Number of Cars, 1913-14.	Number of Cars, 1914-15.
New Jersey.		
Newark,	3	13
Total New Jersey markets,	10	37
Pennsylvania.		
Philadelphia,	180	194
Pittsburgh,	66	16
Total Pennsylvania markets,	262	233
Maryland.		
Baltimore,	30	14
Georgia.		
Atlanta,	6	2
Total Georgia markets,	12	8
Florida.		
Tampa,	11	16
Total Florida markets,	24	20
Tennessee.		
Total Tennessee markets,	13	1
South Carolina.		
Charleston,	2	31
Canada.		
Halifax,	1	10
Montreal,	15	18
St. Johns,	10	19
Total Canada markets,	27	64

The map below illustrates the breadth of the market and the relative importance of each State as a consumer of Connecticut Valley onions.

Fig. 30. — Where Connecticut Valley onions are consumed or reshipped, by States.

Varieties of Onions handled.

The principal competing varieties and the duration of each on the New England markets may be seen by a study of the accompanying diagram (Fig. 31). Strictly speaking, however, three varieties take care of the general onion trade in the New England States. They are the Connecticut Valley, supplemented to a greater or less extent by the New York and Ohio varieties, the Egyptian and the Texas Bermudas. Those from the Connecticut Valley rule from September until April. Texas Bermudas begin about April 10, and are at their height during May, June and July. The Egyptians fill in the gap between the going out of the Connecticut Valley onions and the coming in of the Texas Bermudas.

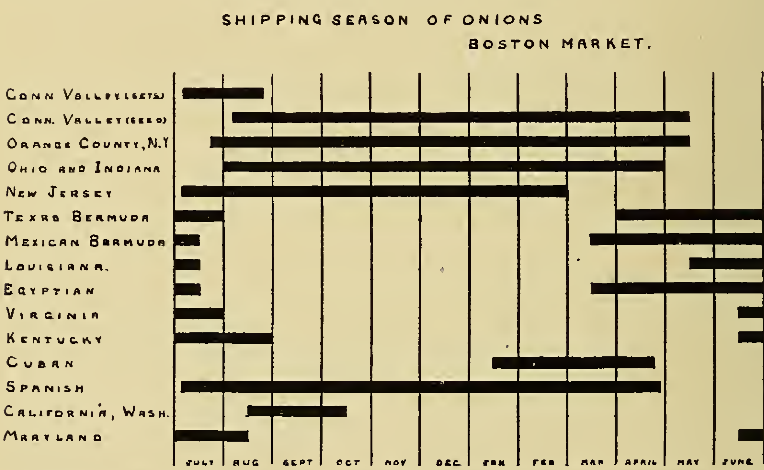


FIG. 31. — Duration of the different varieties on the Boston market. Note the chief competitors. A heavy Texas crop is disastrous to Connecticut Valley sets. The Spanish onions have a special trade, and do not really compete with the Connecticut Valley onions.

The Spanish onion, which is excellent in keeping quality and of very fine flavor, may now be had almost the year round. It has a trade of its own, and can hardly be called a competitor of the three varieties mentioned above. It should be noted, however, that the Ohio and New York varieties arrive on the New England markets about a week later than the onions from the Connecticut Valley and are their chief competitors through the season.

Variations in the Supply of Onions.

The supply of onions for four seasons on the Boston market is graphically represented by Fig. 32.[1]

In studying this chart one is impressed by the marked yearly and seasonal fluctuations. The causes for these may in many instances be

[1] For the supply of onions in the commercial onion-growing belt, see Part I. of this Bulletin.

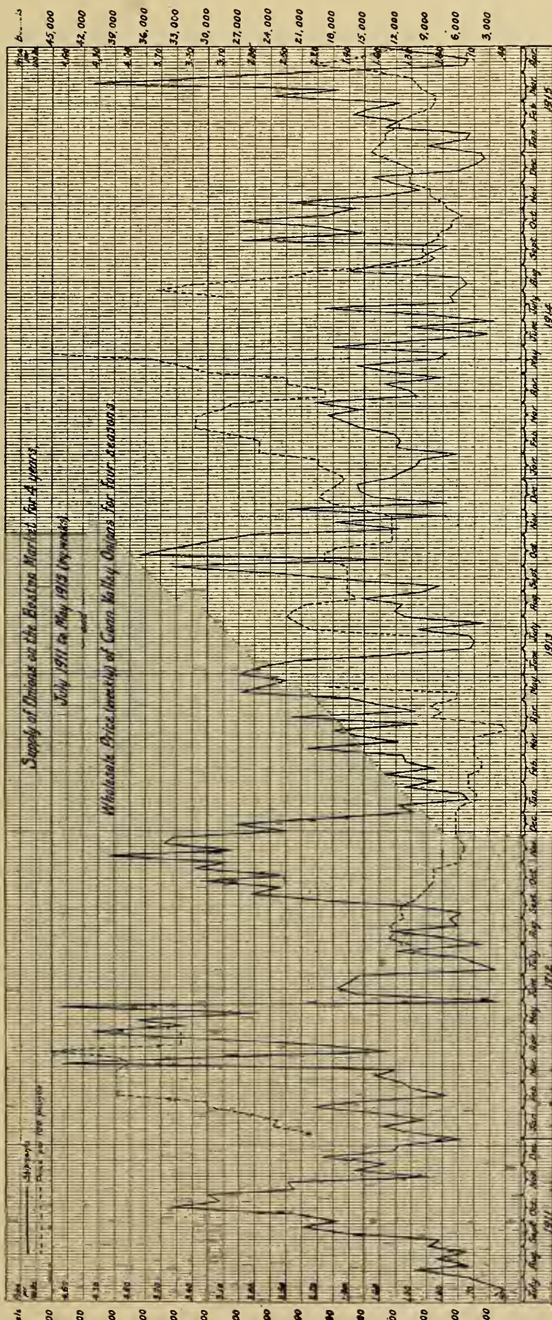


FIG. 32. — Supply of onions on the Boston market for four years, July, 1911, to May, 1915, and wholesale price (weekly) of Connecticut Valley onions for four seasons.

explained. The growing season of 1911–12, for example, was marked by severe droughts which resulted in a short crop of onions, small in size, but of excellent keeping quality. During this season most growers sold early at around $1.50 per bag, which they considered a fair price. But the buyer who sensed the situation stored and sold later at prices ranging from $3.50 to $4.50 per bag. It so happened that the southern crop in 1912 was late and very short because of frosts, which was another lucky break for the storage man.

Following the short crop of 1911 and the correspondingly high prices that winter, a greatly increased acreage resulted and 1912 onion production was overdone. The result was a record crop and very low prices. Then came the reaction, a smaller acreage for 1913, and a yield much reduced by drought and the thrips, but very good prices. The 1914 acreage was again very large, the yield exceptional and the prices very low. In 1915 the acreage planted was about normal, but the quantity harvested was very small on account of the exceptionally heavy rainfall and consequent floods which destroyed thousands of acres in the commercial late onion-growing belt. As might be expected the price was satisfactory to both the grower and the dealer.

Marked variations in the supply may, therefore, be attributed to two reasons — the price the previous season and the general weather conditions during growth and harvest.

Variations in Demand.

For seasoning purposes the onion is used in practically every home, and the demand for good onions continues throughout the year. In this respect it has practically no competing vegetable and is purchased in the small quantities demanded by the average home, no matter whether the price is high or low. In this field the demand is stable or inelastic. In our own markets, however, the demand seems to be increasing, due, first, to the growth of our foreign population, many of whom are from southern European countries and are large consumers of onions, and, second, because the onion is used as a vegetable in an increasing number of homes at all seasons of the year.

Wholesale Prices of Onions on Boston and New York Markets.

The weekly prices of Connecticut Valley onions per 100-pound bag for the four seasons, 1911–15, on the Boston market, according to the Boston Produce Market Report, are plotted on Fig. 32, page 107.

Two other charts are presented. The first (Fig. 33) shows the average *monthly* prices for four seasons on the Boston market. A study of this chart indicates among other things (1) that, in general, an exceptionally good season is followed by a poor one, and (2) that for any one season the September, October and November prices are fairly constant. The second chart (Fig. 34) shows the difference between the wholesale quotations at

New York and Boston. The figures for New York were taken from the New York "Packer," and for Boston from the Boston "Produce Market Report." It is evident from this chart that the differences in price in these markets during a normal season are not very marked.

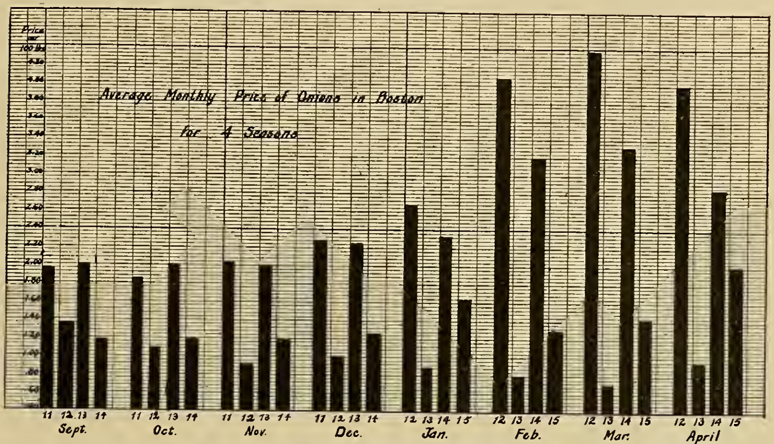


FIG. 33. — Average monthly (wholesale-to-jobber) price for four seasons. This chart shows that it is not always profitable to hold onions. While storage men who held the 1911 and 1913 crops profited greatly by so doing, those who held the 1912 crop lost heavily.

The wholesale prices given above are the prices which the retailer pays to the large wholesaler and jobber. They represent the cost in the valley plus transportation charges, cartage from car to wholesale distributor's place of business, and losses and distributor's profit.

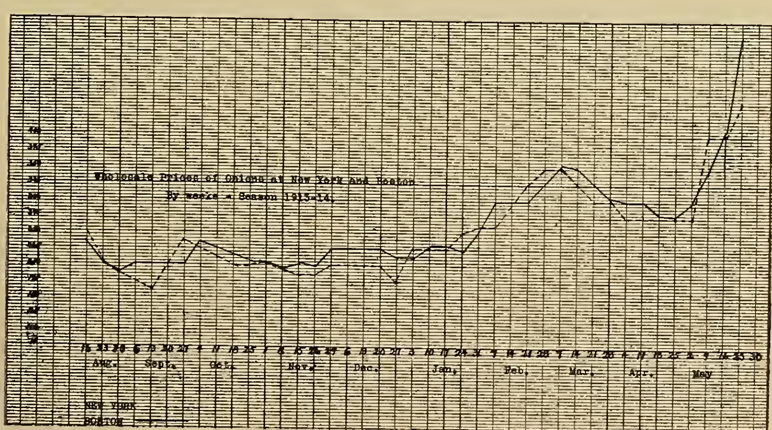


FIG. 34.

Prices to Farmers.

The prices paid to farmers for 100 pounds of onions in 1913, 1914 and 1915 were approximately as follows: —

1913.	
August 10 to 17,	$1 30–$1 45
August 17 to 25,	1 35– 1 40
August 25 to September 10,	1 30– 1 55
September 10 to 30,	1 25– 1 50
October 1 to 30,	1 40– 1 50
1914.	
August 5 to 20,	$1 50–$2 25
August 20 to 30,	1 25– 1 50
September 1 to 15,	75– 1 10
September 15 to 20,	60– 70
October 1 to 15,	40– 60
October 15 to 30,	50– 60
November 1 to 15,	75– 1 00
1915.	
August 20 to 30,	$0 90–$1 00
September 1 to 15,	1 00– 1 45
September 15 to 30,	1 15– 1 50
October 1 to 15,	1 35– 1 65
October 15 to 30,	1 25– 1 40

These prices are for onions delivered at the cars or warehouses. The sack in practically every case is furnished by the dealer without cost to the farmer. Prices paid to farmers show wide seasonal and individual variations; selling the crop a few days earlier or a few days later may make a decided difference in the amount which the farmer receives. Not infrequently the writer heard these statements: "We sold at just the right time, because two days later the bottom dropped out of the onion market completely," or "We made a mistake when we sold so early, because the cry 'overproduction and low prices later' was not true." Both these statements are undoubtedly correct, because the condition of the market does control the price, and the condition of the market in turn is ultimately controlled by the available supply and the effective demand.

But there are other variations in prices — variations between farmers who sell on the same day, often to the same dealer. There are numerous reasons for such variations. They may be the result of an inferior quality, due to inferior culture or soil, or defective methods of harvesting and curing, or possibly failure to give proper attention to grading, bagging or handling. These factors all enter into the making of a standard marketable product put up in the best possible shape. Correctness and reliability of grading and packing are the farmer's "market character," and the buyers are quick to recognize a farmer's reputation for quality and honest practice. Such a reputation undoubtedly pays.

When onions are bought early, *i.e.*, before they are harvested, a contract is generally given by the dealer, and the price to the farmer is the named quotation, but deductions are made if the onions are not delivered in accordance with the terms of the agreement. To make the contract binding, part payment on the crop is frequently advanced by the dealer. Quite frequently the price quoted is for primes, which means that one-half the price will be paid for picklers. The more common practice, however, is to sell the entire product at so much per bag. In any case the farmer does the screening and grading, subject to the conditions stipulated in the contract. Too frequently the producer either willingly or carelessly fails to live up to his agreement. Dealers are emphatic in their contention that owners of land should supervise the screening done by their share tenants. Only in this way, they say, can the responsibility be placed where it belongs.

The diagram below shows the variations in prices paid producers through August, September, October and November for three seasons.

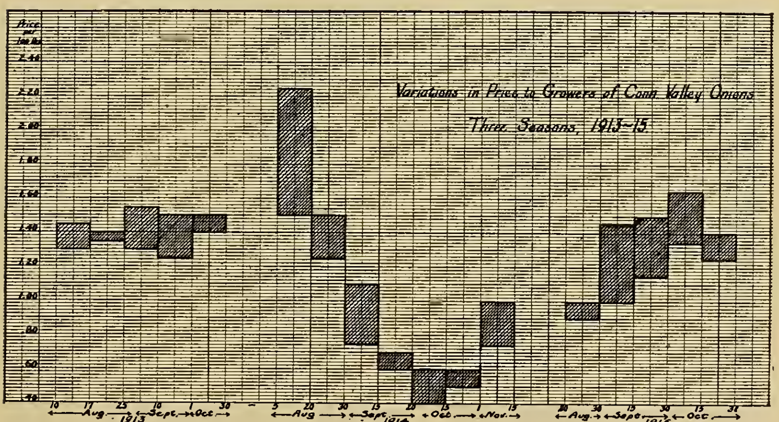


FIG. 35. — Variations in price to farmers. Some farmers must have had onions of inferior quality or lacked bargaining ability.

A study of this diagram is illuminating. Are the conditions of the market wholly responsible for this wide range of prices to farmers? It may explain variations for sales early or late in the season, but it would hardly account for the different prices paid on the same day even by the same dealer for crops of similar quality. It would seem that the producer is to a large extent responsible. At any rate, he is frequently not marketing his product at the best possible price.

If price differences are due to quality then the problems of seed, fertilizer, culture and harvesting should be investigated. If the quality is right then the failure to get the real market value must be explained by the producer's inability to sell advantageously. This is a problem of marketing. To assist in the solution of this problem is rendering first aid to the farmer.

Selling ability depends upon a great many things — a knowledge of general crop conditions, of marketing conditions, of current price quotations, of the onion supply in and out of storage, of the requirements of the market as to standard packing and grading, and upon ability to bargain.

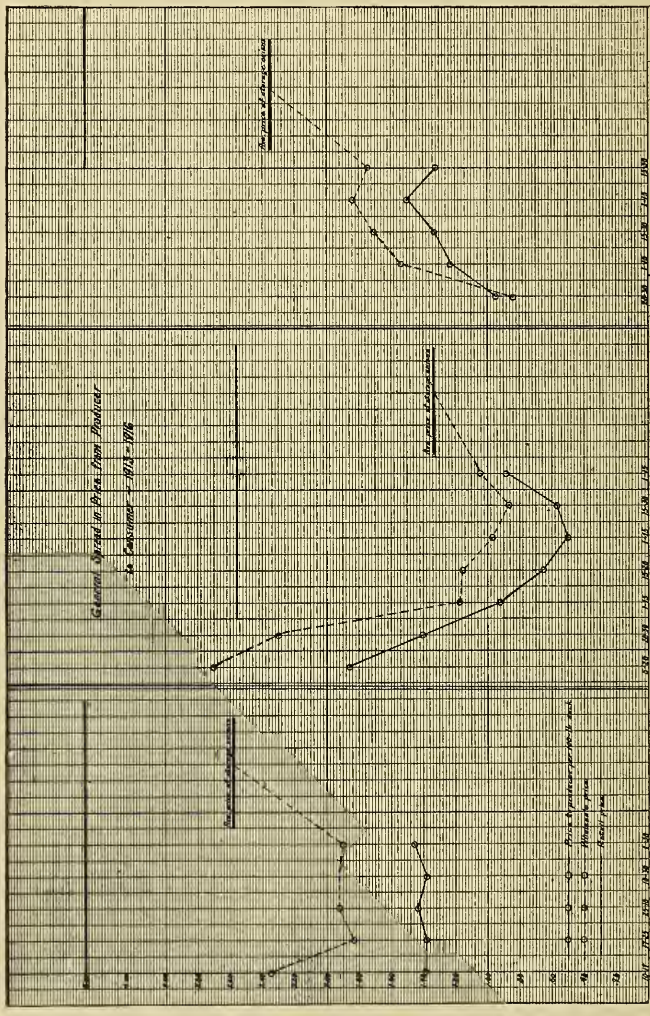


Fig. 36. — Spread in price. The above chart shows the price to the producer during the harvesting season, the wholesale price quotations and the retail price. Notice how the farmer's price compares with the wholesale quotations, and the fluctuations of the latter as compared with the unvarying retail price.

All these are effective selling arguments for the producer. Again, such knowledge must help the farmer in deciding when is the best time to sell. One must always keep in mind that a crop sold from 10 to 20 cents a bag less than the normal market price means a decided curtailment of the producer's income.

In Fig. 36 an attempt is made to show the spread between the price to the farmer, the wholesale price and the consumer's price.

Distribution Routes.

Onions shipped from the valley may reach the consumer through a number of different channels. It is our purpose to point out only the routes which the great bulk of onions takes, and to note the general spread of price from the producer to the ultimate consumer.

Heavy delivery charges and extra expense in the handling and packing of small quantities account for the fact that comparatively few sales are made directly from the producer to the consumer. There are, however, a considerable number of sales made directly to the large retailer, but such sales are usually in quantities less than carload lots.

The vast quantity of onions to be moved and the limited time in which to move them has brought into use our rather complex process of handling them through a chain of marketing specialists. The principal line is from producer to local dealer, to car-lot wholesaler, to jobber, to retailer, to consumer. Another is from producer to local dealer, to broker, to car-lot wholesaler, to jobber, to retailer, to consumer. In Fig. 37 an attempt has been made to show the principal onion-distributing channels. The interlocking circles are employed to show the rather intimate relations which exist between certain agencies connected with distribution; that is to say, certain firms perform the functions of two or three agencies. For example, firms may operate as commission men, car-lot wholesalers and brokers in such a way as to make it difficult to assign them to any definite class of middlemen.

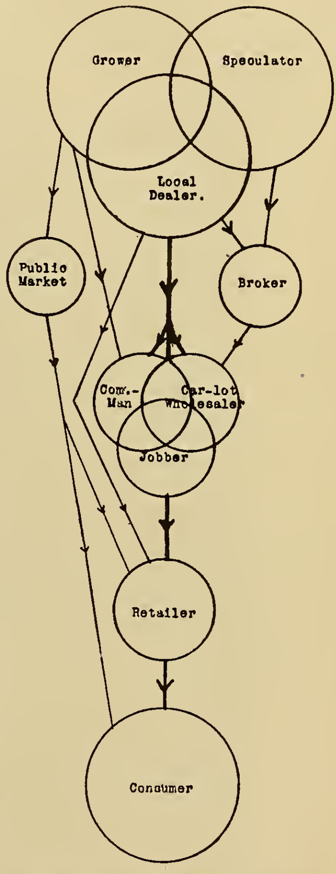


Fig. 37. — Main distributing channels for onions. The interlocking circles are used to represent the close relation existing between certain distributing agencies. The heavy line shows that the bulk of the crop goes from grower to local dealer, to car-lot wholesaler, to jobber, to retailer.

Secondary Distribution.

Primary distribution comprises the agencies engaged in the movement of onions from the farm to the wholesale receiver in the terminal market. Secondary distribution concerns itself with the distribution of onions from the time they reach the wholesaler's hands until they reach the

ultimate consumer, through such agencies as car-lot wholesaler, jobber, wholesale grocer and retailer.

The places of the local dealer, commission man, broker and traveling buyer in onion distribution have already been noted. They come first in the present system of marketing and operate in the valley, purchasing for immediate sale, for speculation or for storage, and are agencies with whom the farmer may deal directly.

Fig. 38. — Delivering onions for the wholesaler. These onions are delivered to the warehouse or directly to retail stores. The drayage charge is 4 cents a bag.

Let us now briefly consider the functions of the middlemen who handle the product after it leaves the valley, *i.e.*, those engaged in secondary distribution.

The Car-lot Wholesaler.

The car-lot wholesaler acts as the primary distributor of onions arriving at the markets by breaking up the carload lots and starting distribution. He usually prefers to purchase outright through local dealers or brokers

and sells to the jobbing or retail trade. When selling to jobbers the prices charged are generally less than those to the retail trade. This is done to protect the jobber and insure him at least a small margin of profit, when he in turn sells to the retailer.

Costs and Profits.

The profits of the car-lot wholesaler vary greatly. Buying outright and in large quantities he has a good chance for wide margins of profit and aims to make as much profit on each sale as possible. Of course,

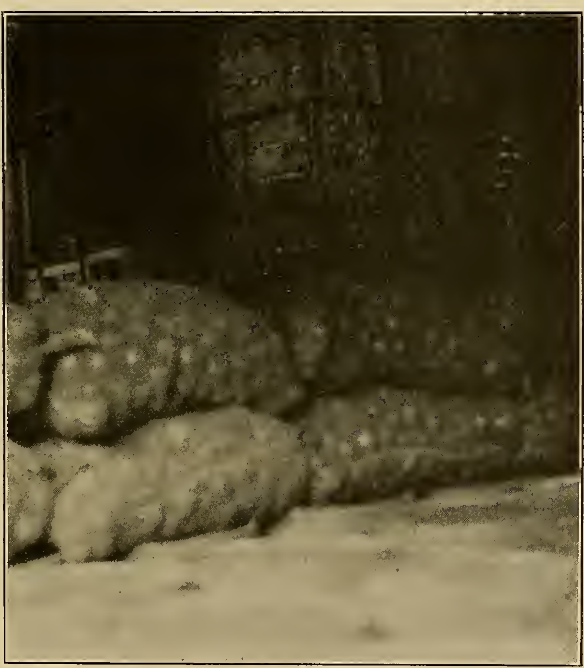


FIG. 39. — Good Connecticut Valley onions at the wholesaler's place of business. No part of the bag needs hiding because this lot is well graded.

the risk he assumes is greater than that of any other wholesale middleman in the chain of onion distributors, with the possible exception of the local dealer.

His business is subject to heavy overhead charges such as rentals, interest on investment and labor. The salaries of the regular salesmen vary from $25 to $85 per week. Considering his services and his cost of doing business his margin of profit is undoubtedly as small as that of any middleman concerned in onion distribution. He must count on 2 per cent. on gross sales for doing business.

Jobber.

The jobber is an intermediary between the commission man or car-lot wholesaler and the retailer. He usually buys from the former in less than carload lots — from 50 to 100 bags — and sells to retailers or other jobbers. His aim is to make quick sales, even on a relatively small margin, his profits coming through the rapid turnover of his capital. The jobber's cost of doing business is much the same as that of the car-lot wholesaler. It includes rent, help and interest on investment.

For the rapid and effective handling of extremely perishable produce his service could hardly be dispensed with, but in the distribution of onions that are properly graded and shipped the functions of the jobber are being assumed more and more by the car-lot wholesaler.

Retailer.

The retailer is last in the chain of distributors. Occasionally he purchases directly from the producer, but usually from the car-lot wholesaler or jobber. In the early fall large retailers frequently purchase a considerable quantity of onions so as to escape the advance in price which comes as soon as onions begin to be shipped out of storage. This accounts, in part, for the heavy shipments during October and November and the light shipments during December.

The various retailing agencies are the general store, the corner grocery, the public market and the street peddler. The retailers, as a rule, sell in small quantities by the pound, quart or peck. Of course in the early fall larger quantities are sold to institutions, asylums and other large consumers. The retailer must add at least 20 to 30 per cent. to the price he pays to cover his expenses and allow for a small margin of profit. As a rule, his prices vary very little during the season. In the early fall he may get his trade "educated," as he calls it, by filling a window with onions and using them as a leader for a week, selling them at a very reasonable price. In the fall of 1915, for example, a large Boston retailer sold onions at 4 cents a pound, 3 pounds for 10 cents, or 35 cents a peck. Later, the price was 5 cents a pound, 6 pounds for a quarter, or 50 cents a peck. Another retailer, running onions as a leader, sold them the first week at 5 pounds for 10 cents. Such sales advertise the onions and serve an excellent purpose in that they introduce another season's product to the public.

It should be noticed that wholesale prices do not group themselves at a certain definite level for the season, but differ even on the same day, within the same State. This is due to the sensitiveness of wholesale prices to such factors as quality, grade, length of storage, shrinkage, middleman expenses and cost of transportation.

In marked contrast to this is the retail price of onions which varies very little during the season, although it is well known that the wholesale cost is not the same; hence, the retailer often appears to be getting too large a share of the consumer's dollar. The fact that in the same city on the

same day onions are retailed at prices ranging from 2 to 8 cents a pound shows that the retailers adjust themselves to their specific trade. Generally, however, the retailer charges a customary price of 5 cents a pound. He needs a wide margin because of waste, the small quantity of onions sold, and the high cost of doing business. This total cost for retail grocery stores, according to figures obtained by the Bureau of Business Research of Harvard University, ranges from 10.4 to 25.2 per cent. of net sales. The most common figure is 16.5 per cent. If the producer is to get more nearly his share he must do it by shortening the route between farm and retailer or consumer, because it does not seem possible that he can do the work of any of the middlemen for less than it is being done now; or he may co-operate with his neighbors and handle distribution along the lines of big business.

General Spread of Prices.

It is exceedingly difficult to analyze price figures with sufficient definiteness to determine price increment added by each of the various agencies through which onions are distributed. In the first place, reliable data on actual charges and prices received and paid by distributors are not readily obtainable; and, in the second place, margins of cost and profit vary greatly through the season and between different distributors.

From data collected at first hand it was found that when onions were selling at wholesale on the Boston market for $2.25 a bag, the retailer was charging $3.50 per bag, or in smaller quantities 5 cents a pound. By tracing this retail price back to the producer, it was possible to calculate with some accuracy the increase made by each agency and the reason for it.

Taking the average figures for the 1915–16 season: —

Ruling price paid by consumer per bag, . . .	$3.50 to $5 = 100 per cent.
Ruling price paid by retailer per bag, . . .	2.35 = 67.1 to 47 per cent.
Ruling price received by farmer per bag, . .	1.30 = 37.1 to 26 per cent.

The farmer's price is for onions sold directly from the field. Hence, the "spread" between $1.30 and $2.35, or $1.05 a bag, represents the cost of the container, costs or charges for storage, shrinkage, local dealer's profit, transportation and drayage charges, wholesale distributor's profit, and, in some cases, a brokerage fee.

The "spread" between the wholesale price, *i.e.*, the price paid by the retailer and the price to the consumer, represents the cost of retailing, losses through wastes and bad debts, and retailer's profit.

In Fig. 40 an attempt is made to present these facts graphically from a different angle. We are to imagine a bag of onions passing from farmer to housewife; as it passes from man to man each handler or distributor takes the toll for his services out of the bag; in other words, each takes his pay out of the onions he handles before he passes on the bag. Of course, the bag grows leaner and lighter as it proceeds. A farmer delivers to the

local buyer 100 pounds of onions. The buyer takes the equivalent of 24.5 pounds for his services; hence, he actually loads on the cars the equivalent of 75.5 pounds. The railroad and drayman take 6.8 pounds, so that the amount delivered to the wholesale distributor is 68.7 pounds. The various wholesale distributors take 13.5 pounds of the 68.7, or about 19½ per cent., so that the retailer receives 55.2 pounds. He, in turn, takes out 18.2 pounds and delivers to the consumer 37 pounds; hence, 63 pounds represents the approximate cost of distributing 100 pounds of storage onions; or, stated in other terms, the consumer pays as much for 37 pounds as the grower receives for 100.

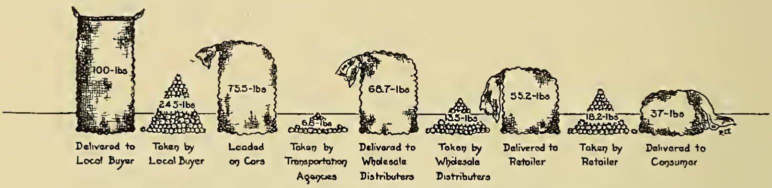


FIG. 40. — The cost of marketing Connecticut Valley onions.

RECOMMENDATIONS.

As a result of this investigation, the following recommendations are made: —

1. There should be in the hands of the farmers more general and definite information concerning the production (acreage, condition and estimated yield) and commercial movement of onions in and from the commercial onion-growing areas of the United States. Data from these sections are of great value in deciding upon the proper time for selling the crop.

2. The average onion grower is not giving sufficient attention to the problems connected with the curing, screening and grading of onions. The quality of the crop and the condition in which it is delivered to the buyer have a marked effect on the price. The requirements of the markets which are supplied with Connecticut Valley onions should be carefully studied and promptly met. This naturally demands a knowledge of the breadth of the Connecticut Valley onion market.

The grower would do well to supply his own bags and have them properly marked with his name and address as a guarantee of his willingness to stand back of his product. Harvest carefully, grade conscientiously, brand honestly and one has gone a great way towards insuring a satisfactory price.

3. Most growers are unable to store because they need immediate cash returns in order to pay existing debts. For such, co-operative selling associations would be helpful or some arrangement by which loans could be obtained by depositing warehouse receipts as collateral. Such receipts are now given by many cold-storage corporations as soon as products have been placed in their storages and, in many instances, loans are made on

such holdings. It would seem that the local storage men might issue these receipts to the growers whose onions are held in their warehouses.

4. The holding of onions in storages is generally advisable, but to do this with profit a knowledge of the available supply and general market conditions is absolutely essential.

5. To guide him in selling to the best advantage the grower should have more exact information of market conditions and prices. At present farmers sell more or less blindly. Newspapers, produce reports, market bulletins and trade-papers help, but they are not sufficiently accurate or definite to be of much real assistance to the farmer. Price quotations and market reports carefully compiled by State or Federal market bureaus should be made available to all growers.

But much of the advantage gained in this way will be lost to the farmers, because they cannot hope individually to learn everything about marketing and distribution. Moreover, a hundred farmers can hire a marketing expert to handle their products by organizing themselves into a growers' mutual marketing and purchasing agency, operated on a strictly co-operative basis.

The market demands of the producer dependable goods, packed uniformly and neatly, well graded and shipped regularly in sufficient quantities to meet the demand. These can hardly be met by the individual farmer and because they cannot be met the retailer and consumer naturally go to the various middlemen for their onions. Organization and co-operation among onion growers would help to solve many of the existing marketing problems. It would also assist in disposing of onions through the auction route.

6. The onion farmer should make more use of the various agencies which are in a position to assist him in an unprejudiced way to produce and market his products.

Some of the agencies are as follows: —

(1) The Federal Office of Markets, Washington, D. C. This office assisted the Texas growers in a very definite way during the season of 1915–16. About April 1, two men were stationed in Laredo and other points in Texas to report the movement and distribution of car-lots of onions. At the same time representatives were stationed in twenty or more cities of the United States where onions are shipped largely, to report the daily market conditions and prices. The information collected in these cities was telegraphed each night to Laredo, where it was compiled and distributed for the benefit of those interested.

One function of the office is to assemble market information and make it public in such a way that the distribution of the crop and the prevailing market price can be known by any one. Each individual shipper can guide his action accordingly, without making known to any one else the details of his business.

Recently the department extended this service to include the onions produced in the Connecticut Valley. Certainly, such information covering

shipments, receipts and market prices of onions should be of great value, both to growers and dealers.

As a sample of the information disseminated, one of the bulletins issued by the United States Department of Agriculture to Connecticut Valley growers during the early fall of the 1916 onion season is reproduced below.

ONION SHIPMENTS August 24, 1916

Massachusetts, 6 (2 Boston); New York, 9; New Jersey, 7; Ohio, 4; Indiana, 3; California, 8; Washington, 10. *Previously unreported;* Aug. 20: California, 11.

TELEGRAPHIC REPORTS OF TODAY'S MARKET GIVING JOBBING PRICES (WHOLESALER TO JOBBER)

BOSTON: 2 Wash recd. Mkt steady dem moderate. Wash Walla Wallas Yellow Globes qual cond good 100# bags mostly $2.25. Conn Valley qual cond gen good 100# bags $2.25. Natives in bushel boxes $1.25–$1.35.

PHILADELPHIA: Mkt weak dem limited. Qual cond fair. 100# sacks Yellow Globes Ohios $2.25–$2.35. Ill 100# sacks Yellow Globes $2.60. Western bu Whites $1–$1.25 Picklers $1.50–$1.75. Jerseys bu hampers $1–$2. 3 N J arrived, 2 unloaded, 2 track. 3 Western arrived, 1 unloaded, 2 track. 1 Mass unloaded, 1 Penn track.

NEW YORK: Unloads 1 Iowa, 3 Ind, 1 Penn, 3 N J, 8 N Y, 1 Cal, 1 Unknown origin recd. Jerseys qual ordinary cond good dem slow bu hampers $1–$1.25 (yellows), Whites $.60–$1, Ohios and Ind qual cond gen good dem slow Strd crates Whites $1.10–$1.50 few sales 100# sacks Reds qual fine cond good dem good $2.50. N Y qual fair cond good dem slow bu hampers Reds $1–$1.25 Yellows $.75–$1.25 100# sacks Yellows $1.25–$2.40 100# sacks Reds $2–$2.37½, bu hampers Whites $.60–$.70. Washingtons qual cond fair overlarge dem slow 100# sacks $2–$2.25. Iowas qual cond good mkt dull dem slow 70# sacks Yellows $2 few sales. Long Islands qual cond good small 100# sacks Yellows $3.50

The Federal Office of Markets also issues many bulletins on marketing problems which may be had by addressing the Federal Office of Markets, Washington, D. C.

(2) The Massachusetts State Board of Agriculture, State House, Boston. This Board is vitally interested in the development of the agricultural resources of the Commonwealth, and is spending considerable time and money in disseminating useful agricultural information through lectures, demonstrations, reports, institutes and correspondence.

(3) The Massachusetts Agricultural College. The college, more especially through the Experiment Station and its Extension Service, is in a position to render valuable aid to Connecticut Valley farmers. The Experiment Station, especially concerned with specific problems of Massachusetts agriculture, stands ready to assist in every way possible, both in problems of production and distribution. Its various bulletins are free, and may be had by addressing the Director of the Experiment Station, Amherst, Mass.

The Extension Service, through its force of instructors, its extension schools, and its publications, is bringing assistance directly to the community and the producer. Address, Director of Extension Service, Amherst, Mass.

Summary.

1. The commercial onion-growing areas of the United States are well defined. Data concerning crop conditions in these areas are valuable as market guides.

2. The Connecticut Valley by virtue of its rich soil and foreign labor supply is well adapted to onion growing.

3. In close proximity to the large eastern markets, and with excellent transportation facilities, onions can be readily marketed. Land suitable for onion growing is still available, and extension of the industry is possible whenever economic conditions warrant it.

4. Land values have steadily increased, so that good onion land sells for from $200 to $500 an acre, and rents at $35 to $50 an acre.

5. The Yellow Globe Danvers is the leading variety grown. Red onions are not grown extensively, because New York and the west can produce them more cheaply.

6. The cost of raising and lifting a bushel of onions in 1915 was approximately 35 cents; of topping, screening, bagging and hauling to shipping point 6.8 cents.

7. Onion growing on shares requires little capital, and many foreigners with limited means are engaging in the industry.

8. The average yield per acre is from 400 to 500 bushels.

9. While it is possible to crop certain parcels of land continuously with onions, it is not advisable. Some system of crop rotation should be practised more generally.

10. Most of the onions produced in the Connecticut Valley are seed onions. Set onions are raised at a greater expense, but, in years when the Texas crop is short, sets are a valuable crop.

11. Accurate crop reports from the Bermuda onion districts are a good index as to the quantity of sets Connecticut Valley growers should raise.

12. Onions not intended for storage should be fairly ripe when pulled. After pulling, care should be exercised to prevent rotting and injury from exposure to sunshine and rain.

13. Onions intended for storage should be pulled while still somewhat green and stored as soon as possible after the roots have dried a little.

14. Careful attention should be given to the screening and grading of onions.

15. The problems of marketing Connecticut Valley onions are more serious than the problems of production.

16. More than 75 per cent. of the Connecticut Valley onions are bought by local dealers who are also storage men. Very few are consigned to commission merchants.

17. Sales to local dealers and traveling buyers are advantageous in that the grower deals with the buyer in person and receives cash at the time of sale.

18. Selling onions directly from the field transfers the risks of holding from the producer to the buyer and turns the crop into immediately available cash.

19. Sales of onions direct to the retailer or consumer are necessarily few, because under present methods of distribution most car-lot shipments must be sold through wholesale distributing agencies.

20. The local storage capacity is approximately 600,000 bushels.

21. The quantity of onions held in local commercial storages in December does not show very marked variations from year to year.

22. The actual cost of storing in the valley is about 11 cents per 100 pounds.

23. The average seasonal shrinkage in local storages is approximately 10 per cent.

24. The charge for hired storage is from 23 to 25 cents per 100 pounds.

25. The shipping season for Connecticut Valley onions lasts from the middle of July to the beginning of May.

26. Onions are sold out of storage from December until May. The month of heaviest shipment is March.

27. Allowing liberally for overhead charges, shrinkage and extra handling storages are a profitable investment.

28. Cold-storage facilities for onions may be had in Boston and New York. Onions are seldom placed in these storages before March 1.

29. Practically all shipments are made in 100-pound bags. A carload contains 250 bags.

30. The primary shipping points for Connecticut Valley onions are the principal cities of the New England and Middle Atlantic States. In recent years a considerable quantity has been shipped to the South Atlantic States and Canada.

31. The three chief varieties for the New England markets are the Connecticut Valley, Egyptian and Texas Bermuda.

32. A year of exceptionally good prices is likely to be followed by one of large production and low prices.

33. The three-year average (1913–15) price to the farmer was about $1.14 for 100 pounds of onions, as compared with the average wholesale price for onions out of storage, which was about $2.20 per 100 pounds.

34. The retail price of onions is fixed largely by custom, varying little from 5 cents per pound.

BULLETIN No. 170.

DEPARTMENT OF BOTANY.

SHADE TREES, CHARACTERISTICS, ADAPTATION, DISEASES AND CARE.

BY GEORGE E. STONE.

Introduction.

The general interest in shade trees, particularly in the eastern States, well illustrated by the amount of money expended upon them and the many questions asked concerning their welfare, has created a demand for a brief, practical bulletin covering the various questions relative to shade trees and their management. Bulletin No. 125, issued in 1908 by the Massachusetts Agricultural Experiment Station and the Massachusetts Forestry Association, covered the subject in a general way, but the publication is now exhausted.

Shade trees add greatly to the desirability of a community as a place of residence, and their æsthetic value cannot be estimated in dollars and cents. It is no exaggeration to say that the complete destruction of all the trees and shrubbery would reduce the valuation of some cities and towns very materially.

Trees also possess a utilitarian value which is recognized by the courts, and for the careless destruction of street trees the abutter is entitled to compensation. A street tree adds value to real estate in the same way that a sidewalk or curbing does, but while the sidewalk and curbing may deteriorate, a tree increases in value for many years; for example, a tree originally costing $2 to set out may be worth $150 in sixty years, which is equivalent to 7½ per cent. compound interest on the investment.

Too much emphasis cannot be laid upon the care of shade trees. In common with crops they give the best results under cultivation, but unfortunately the best conditions do not always exist. Trees grow fairly well on lawns, however, especially when the lawn is occasionally fertilized. Conditions on congested streets are quite different. Many of the trees on our village greens, where often little attention is given to their care, show neglect and need of better treatment. In many places they have

been growing for years in sod to which no fertilizer has been applied and a hay crop removed annually, and in such cases one year's use of a plow and harrow, together with manuring and some kind of cropping, would work wonders in restoring them.

In applying remedies to trees it is well to be on the conservative side, since it is a very easy matter to cause them serious injury. The different spraying mixtures, etc., recommended for trees are not always to be depended upon, and many trees are injured by their use; hence a word of caution is not out of place. Unfortunately, at the present time it is necessary to be on the watch for fake "tree doctors" who often do more damage to trees than good. This class of so-called "tree experts" has greatly increased within the last few years, and in some localities has become a nuisance. The "tree faker" is not only ignorant and incompetent, but is dishonest and a "divine right" fiend. There is another class of workers who may be ignorant, but honest; and still another class possessing some intelligent ideas as to tree work and a desire to be conscientious, but they fail to produce the best results. The men who possess sufficient technical knowledge and skill to undertake work on trees are comparatively rare, although fortunately there are a few competent firms and professional men who are capable of giving advice in regard to the treatment of trees.

The tree warden should be, and often is, a man of intelligence and common sense, and one to be called upon for advice pertaining to trees.

Requirements of Shade Trees.

As a rule, those trees should be planted which are known to thrive well in the particular environment under consideration. The fact that a tree does not grow naturally in one locality is no evidence that it will not thrive in some other, and it is well known that species of trees peculiar to wet places will grow in those inclined to be dry; but there is a limit to the adaptability of trees as regards their best growth and development which should be taken into consideration. A species naturally adapted to a wet environment is more likely to suffer from the effects of extreme meteorological conditions when planted in a dry situation than one normal to such places. The nature of the soil environment is, therefore, important; and there are many other factors which enter very largely into the problem of selection and planting of shade trees. Naturally there is a considerable difference of opinion in regard to what are the best trees to plant. It is important, therefore, to choose those species which are best adapted to the conditions under which they are to be grown, all trees having their weaknesses and defects, and perfection being no more common to trees than to the human race. The past decade has been characterized by extremely erratic conditions, such as unprecedented drought during the growing season, and severe winters, both of which have been responsible for so much deterioration of trees that the question of selecting resistant types has been a vexing one. Moreover, the presence

of destructive insects and fungous pests, which heretofore have not been troublesome, has rendered the problem still more perplexing.

Some of the factors which enter into the problem of selecting species and varieties for shade trees are the following: —

Adaptability to Climatic Conditions.

One of the first requisites in selecting a tree for street planting is a knowledge of its climatic requirements. Many species of trees are likely to suffer from extreme meteorological conditions, and even species indigenous to a certain region may prove a failure when planted in a city or town as shade or street trees. There are also certain species which have their limitations as regards climate, such as some Japanese varieties, and in planting this should be taken into account. Under adaptability to climatic conditions is included the ability of a species to withstand the detrimental effects resulting from heat and cold, wind, snow and ice, atmosphere and soil moisture and light intensity.

Hardiness and Resistance.

Hardiness and resistance are the capacity of a species to withstand extremes of climate and the more or less abnormal and severe conditions of the particular environment in which it may be placed. These may arise in part from the peculiar atmospheric and soil conditions which are characteristic of congested settlements where the soil has been made from various types of refuse, or may be due to the presence of large manufacturing establishments.

Configuration and Conformity.

The shape or form of a species, as well as its conformity to its environment, is essential. Wide avenues demand different species from narrow avenues; and the habit of branching, root development, height, spread of the crown and general symmetry of the tree should be considered.

Longevity.

The age which a species is capable of attaining is important in its selection for planting, and while short-lived trees may have their use in certain places for temporary growth, a longer-lived variety should be selected for permanent effects. While the causes underlying senescence and rejuvenescence are hereditary in individuals, the life and usefulness of a tree may be prolonged by treatment, and its configuration greatly modified. Some trees, such as the apple, are readily rejuvenated, while others respond very poorly to treatment.

Rapidity of Growth.

The growth of trees in general is quite variable. Even individuals of the same species are different in this respect. Much also depends on environment in the growth of trees. The modern tendency in tree plant-

ing is to secure quick results; hence during recent years much use has been made on streets of the Carolina poplar and soft maples instead of the better and more slowly growing species, such as rock maples, elms and oaks. Excepting a few rapidly growing trees like the poplars and others, there is not much difference in the rapidity of growth of different species if they are given ideal conditions. While the production of quick growths is quite legitimate in planting, the idea of a permanent effect should not be lost sight of; and it is possible to accomplish both of these results by methods of planting.

Shade Production.

The amount of shade produced by any kind of tree depends on the shape of the crown and the density of the foliage. The more rapidly a tree grows the more quickly shade is secured. The shape of the crown varies with different species, but may be readily modified in such trees as the poplar by pruning. Shade constitutes the important feature in street trees, and is perhaps the most essential qualification of an ornamental tree.

Root Peculiarities or Habits.

The nature of the root development is an important factor in the selection of shade trees. Such trees as the maple and elm possess large, spreading root systems which are generally interfered with by street repairs, excavations, etc., while some other trees more restricted in their root development more often escape injury. The tendency of the roots of some trees to penetrate drainage and sewer pipes is an objectionable feature, as is also the upheaval of sidewalks, dislocation of curbings, etc., which result from the root development of certain species of street trees.

Neatness.

Much objection is often made to species like poplars, horse-chestnuts, etc., that produce litter, which requires frequent cleaning up. Some fruits, such as the mulberry, are mucilaginous and often become dangerous on sidewalks. Nut trees are also likely to be objectionable on residential streets because of the nature of their fruit and the liability of injury to the trees when it is gathered. It should also be mentioned that certain trees — such as the staminate form of Ailanthus — which emit disagreeable and irritating odors are undesirable.

Æsthetic Value.

The modern civic requirements in street planting demand not only the selection of healthy and vigorous trees and their general adaptation to the physical conditions surrounding them, but the consideration of beauty, taste and general arrangement as regards surroundings and conformity to an intelligent treatment, or, in other words, the æsthetic and landscape features. At the present time city streets are often provided with

parkways which are planted with shrubbery and trees, and consequently both the nature of the species to be planted and the arrangement of the individual trees should be studied in order to have them conform with the general surroundings. This point of view of the matter is important and should not be lost sight of, since the æsthetic arrangement of streets and avenues adds to the value of adjoining estates in general.

Susceptibility to Insect Pests and Diseases.

Injurious fungi and insects are indigenous to every community, and many new pests are constantly being introduced, so that it is impossible to draw definite conclusions as regards immunity or susceptibility of any species of shade trees or ornamental shrubbery to those organisms. Judgment upon the probability of injury in any particular case must be based upon individual experience. There are scarcely any shade trees, however, which are not regularly affected by certain insects and fungi, and they are, moreover, subject to local and sporadic attacks. Trees which are exceptionally susceptible to insects, fungi and other injurious factors should be sparingly planted.

Commercial Importance.

Street trees are, as a rule, not planted for any commercial consideration, and the commercial idea should always be a secondary one. It happens, however, that sometimes the nature of the growth along country roadsides is such that thinning may advantageously be done, much good timber thus being obtained by the abutter; but this thinning should be done with discretion. There are also quite a few trees, such as the basswood and tulip, for example, and many shrubs, that are valuable as honey species, and their utilitarian value in this respect should not prevent their selection for planting. In European countries fruit trees are often planted along the country roadsides, where they not only serve ornamental purposes, but have a distinct commercial value in the production of fruit.

Street and Roadside Trees.

American Elm (*Ulmus americana*). — This is one of the most widely planted trees in New England, where it reaches its height of perfection. It is generally symmetrical in outline, attaining a good age, one hundred to three hundred years, and often large dimensions. The best developed types are majestic and more beautiful than any other tree known. According to Olmsted Brothers, landscape gardeners, "there is no other sort of tree which gives the effect of a lofty, over-arching canopy of foliage, which observation of village greens leads us to believe is the effect mostly to be desired." It is difficult for an elm to thrive on dry, gravelly soil, and when located in such situations it is inclined to be lanky, develops slowly, and is unhealthy in appearance. It is best suited to a fertile, more or less moist soil where fine sand and silts predominate, and is well adapted

to lawns and roadsides, but not at all to mowings. The high branching habits of this tree render it the best type we have for streets on which there are numerous wires. In recent years it has become infested with such insects as the elm-leaf beetle, and most disastrously by the leopard moth. It has suffered more of late from the effect of drought than any other tree, and extreme cold has affected its root system to a considerable extent. These defects have been the means of discouraging its planting. The elm has a habit of occasionally shedding its leaves and twigs, and is sometimes affected by a leaf fungus (*Dothidella*).

Fig. 1.—The Lancaster elm.

Slippery Elm (*Ulmus fulva*).—Occasionally the slippery elm is planted by mistake for the American elm. It is, however, a much smaller and inferior tree.

English Elm (*Ulmus campestris*).—This tree, which attains a large size, is a handsome species, and was formerly planted more extensively, at least in certain localities. It is, however, more susceptible to the elm-leaf beetle than our native species. Other elms which may be mentioned here are the Scotch elm (*U. montana*), which is occasionally seen; the Cork elm (*U. racemosa*), a tree of fairly good size with a corky bark and of slow growth; and the Japanese elm (*U. japonica*), a handsome, symmetrical tree of rapid growth, little known in America. Although affected to some extent by the elm-leaf beetle, this elm gives promise of becoming a valuable shade tree.

Fig. 2.—Type of feathered elm.

Rock Maple (*Acer saccharum*).—The maples as a whole have been more extensively used for street planting than trees of any other group. The rock maple, like the elm, has been extensively employed as an ornamental tree; indeed, there is no species that has been used more widely for lawns and avenues than the rock maple. It is one of our handsomest trees, being characterized by unusual symmetry and dense foliage. It

develops rapidly under good soil conditions, and occasionally will attain a diameter of 12 inches in fifteen or sixteen years. In some situations it grows to be an enormous tree, and quite often attains an age of one hundred and fifty years or more. The rock maple is sometimes affected with a leaf spot, and is more susceptible than any other tree to sun scorch and bronzing of the foliage. It is also quite susceptible to frost cracks. During the past five or six years this tree has suffered much from extreme drought, and as a result many staghead specimens are to be seen.

FIG. 3 — Rock maple growing in pasture.

WHITE OR SILVER MAPLE (*Acer saccharinum*). — This species is not equal to the rock maple, either from the point of view of durability or of beauty, and it is too commonly disfigured by ice and winds. It grows very rapidly, and in southern New England, where magnificent specimens may occasionally be seen, it attains a great size. It is planted on avenues and lawns to a very large extent, but the drooping habit of its branches, together with its liability to injury, affect its value somewhat for street planting. In most situations its real value consists in its rapid growth and ability to produce quick shade effects. It is attacked by a leaf spot fungus (*Rhytisma*) which, however, does little harm.

RED MAPLE (*Acer rubrum*). — The red maple is a tree of rapid growth, well adapted to swamps and fairly moist places. It has been planted quite extensively on streets, often, no doubt, in mistake for the rock maple. It develops large branches, usually rather low, which should be pruned at the

FIG. 4. — Avenue of elms planted close.

time of transplanting. The foliage of the red maple is inferior to that of the rock maple both as regards color and density. This species has suffered much from drought and winterkilling of roots, which is characterized by a "staghead" condition. The leaves are often conspicuously spotted by the fungus *Rhytisma.*

Norway Maple (*Acer platanoides*). — The Norway maple is a wide-spreading tree, with large leaves which give a dense shade. It is well suited to lawn planting, and is highly regarded for streets and roadsides. The Norway maple is perhaps at the present day one of the most extensively planted street trees, especially in cities. It is a rapidly growing tree, and, at least when young, is very symmetrical and well adapted to city conditions. However, whether the Norway maple will in the long run prove equal to the rock maple as a shade tree under severe city conditions is a question. When planted in unfavorable locations it is sometimes badly affected with sun scald, and the small terminal branches sometimes winterkill and become affected with the cinnamon colored fungus *Nectria.*

White Oak (*Quercus alba*). — This species is seldom planted as a street tree because of its slow growth. Its habits of branching are not always well adapted to streets, although it makes magnificent individual specimens for lawns and roadsides. It is occasionally affected by a leaf fungus (*Glœosporium*) and by various insects, and is one of the preferred food plants of the gypsy moth.

Fig. 5. — Specimen of red oak.

Red Oak (*Quercus rubra*). — In former years little consideration was given to the red oak as a street or ornamental tree, although recently it has received much well-deserved attention. At present it ranks among the first as a species possessing all the required qualifications for planting. The growth of the red oak is quite rapid; it is symmetrical and clean in appearance and exceptionally free from injury resulting from insects, fungi and other causes. It is adapted to a variety of soils, quite easily transplanted, and should be more extensively used as a street and country roadside tree.

Black or Yellow Oak (*Quercus velutina*). — This oak is often found associated with the red oak, but will tolerate much drier soils. It does

possess, however, the qualifications of the former species, and is best adapted to country roadsides.

Scarlet Oak (*Quercus coccinea*). — The scarlet oak is one of the most beautiful oaks in New England. It is adapted to the driest and poorest of soils, often being associated with the black or yellow oak. It is a tree of slow growth, and on this account has been planted very sparingly in the past. Recently, however, it has come to be more appreciated. The beautiful scarlet foliage, characteristic of this tree in the fall, is much admired. It is well suited to dry, gravelly soil where other trees, such as the elm, will not thrive. In some cases it has been effectively alternated on country roadsides with some tree of rapid growth, as the Carolina poplar, the poplars being removed when the oaks have reached a fair size. The scarlet oak is worthy of much more attention as a shade tree than it has received, especially for suburban streets and country roadsides.

Pin Oak (*Quercus palustris*). — The pin oak has its northern limit in Massachusetts, and in the Connecticut valley, where it is found quite abundantly, it becomes a handsome tree. It naturally grows in rich, moist soil and often in water, and appears not to tolerate too dry conditions. The symmetrical, triangular or pyramidal shape of the crown and its drooping branches give it an individuality distinct from other trees. The growth characteristic of this tree in New England appears to be somewhat different from that further south, as is the case with most trees. In the north it appears to retain its youthful form longer than elsewhere. It should be planted in soil having a texture capable of holding moisture, and the addition of organic matter is advisable. Under desirable soil conditions the pin oak attains a diameter of 6 or 7 inches in nine or ten years. It is well adapted to narrow streets, and especially to lawns and parks. The characteristic drooping habit of its limbs necessitates careful and high pruning when planted on streets. The pin oak resembles the red oak in being relatively free from troubles induced by insects, fungi, etc., and may be considered one of our most promising shade trees.

Mossy Cup Oak (*Quercus macrocarpa*) and swamp white oak (*Quercus bicolor*) are sometimes planted on country roadsides. The latter, which makes slow growth, is adapted to wet places.

Basswood or American Linden (*Tilia americana*) is a native of New England, but is seldom planted on streets, although it is adapted to certain locations. It is a beautiful tree — with bright green foliage, graceful and symmetrical when young, but when planted too closely it loses its lower limbs and is inclined to early deterioration.

European Linden (*Tilia sp.*). — The linden has been much planted as a shade tree, and is a good tree when young and vigorous. The tree is not as a rule long lived, and it is often subject to sun scald and frost cracks from which it deteriorates rapidly. It is also likely to be affected with sooty mold, which follows the honeydew secretions of aphids. This materially affects the appearance of the tree. There are several species

of linden under cultivation which possess distinctive characteristics, and these have been sadly confused by nurserymen. The two species most commonly planted are *T. vulgaris* and *T. platyphyllos*. According to H. J. Koehler,[1] *T. vulgaris* is one of the best trees to plant, while *T. platyphyllos* is one of the worst. Excellent types of lindens may be seen in the Arnold Arboretum, some of which will perhaps eventually prove superior to either of the above species.

Fig. 6. — Avenue of lindens.

Horse-chestnut (*Œsculus hyppocastanum*). — The horse-chestnut, like the linden, was introduced from Europe, and has been much planted on streets. It grows rapidly, but it is not, as a rule, a long-lived tree. It is affected by a leaf-spot fungus (*Phyllosticta*), sometimes losing much of its foliage on this account, and often many of the twigs are winterkilled and affected with *Nectria*. It is also susceptible to sun scald and frost crack, and the amount of litter produced by the fruit is somewhat objectionable. The red-flowering horse-chestnut is occasionally planted and is preferred by many.

Sycamore (*Platanus occidentalis*). — Fine individual specimens of our native sycamore may often be seen on lawns and roadsides in New England, but it has been used in the past to a limited extent for avenue effects. The sycamore has a wide range, being confined in the north to river valleys. It naturally prefers a rich soil, and when transplanted under good conditions it attains a large size. The sycamore will endure any amount of pruning, and can be adapted to any street, even the busiest thoroughfares. Much more use is made of the sycamore than formerly, especially in cities, and the oriental species (*P. orientalis*) is also much employed. The sycamore is severely affected with a leaf-spot fungus (*Glœosporium*) which often causes serious defoliation. The younger twigs sometimes winterkill badly, but the tree will stand a great deal of hard usage and mutilation.

Ailanthus (*Ailanthus glandulosa*). — The Ailanthus may be termed a "scavenger tree," as it will grow anywhere and will endure more trying conditions than any other tree. It is frequently found growing along railroad embankments, on dumping grounds, — in fact, no conditions seem too severe for it. It is used to some extent as a street tree, and excellent individual specimens may be seen here and there. Where quick effects are desired it is worthy of consideration. The Ailanthus, which is a native

[1] Landscape Architecture, July, 1915.

of China, is often termed the "tree of heaven," concerning which Dr. Asa Gray has well remarked that its blossoms are "redolent of anything but airs from heaven." To obviate the disagreeable odors arising from this species only the pistillate trees should be used for planting, the disagreeable odor being given off by the male or staminate flowers, which are often borne on separate trees. The Ailanthus apparently tolerates obnoxious atmospheric gases better than most other trees.

Tulip Tree (*Liriodendron tulipifera*). — This is an excellent tree for roadsides, although it is not very much planted. It is probably better

Fig. 7. — Avenue of pin oaks transplanted seven years in 40-foot avenue.

suited to lawns and country streets than to the hard usage it might receive on city streets. The tulip is indigenous to different parts of New England. It is a difficult tree to transplant successfully, and this may account for its not having been more extensively employed. This species attains a large size, developing a large symmetrical crown with handsome foliage. It requires good, well-drained soil, and is best adapted to wide avenues provided with generous tree belts. The leaves sometimes become badly spotted from attacks of insects and fungi, but the loss in transplanting and its lack of adaptability to certain situations are the chief objections to its use as a street tree, at least in the north.

White Ash (*Fraxinus americana*). — This ash is commonly seen on streets. It was formerly planted more extensively than at present. Our measurements of a number of white ash trees which had grown in good

soil and which were twenty-two years old showed an average diameter of 16 inches, while others grown in dry, gravelly soil attained an average diameter of only 12 inches during the same time. The white ash develops a widespreading top, and is a fairly desirable shade tree, although in too dry locations it may become affected by borers and scale insects. It has suffered much in recent years from drought, winterkilling and in some locations from a rust (*Æcidium fraxini*). Other species of ashes, like the black ash, are occasionally planted accidentally for the white ash.

Cucumber Tree or Magnolia (*Magnolia acuminata*) has been highly recommended by some authorities for roadside planting. It has been employed extensively as an ornamental tree, but no attempt so far as we know has been made to utilize it as a street tree in the north.

Sweet Gum (*Liquidambar styraciflua*) is a native farther south, Massachusetts appearing to be a little too far north for its best development. At any rate we have observed no satisfactory growth of this species in this section. It is subject to winterkilling and frost cracks in the north.

Ginkgo (*Ginkgo biloba*), a Japanese species, is occasionally seen on lawns, and forms a beautiful avenue on the agricultural grounds at Washington, D. C. Well-developed individual specimens of Ginkgo may be observed here and there in New England, and this tree has been used to some extent for street planting. It is adapted to a wide variety of soils, and is remarkably free from diseases. It develops a narrow cylindrical or conical crown, which adapts itself to narrow streets. This species is undoubtedly better adapted to planting farther south than in New England; nevertheless, it possesses many qualifications as a desirable street tree, and should be utilized for this purpose in suitable locations.

Carolina Poplar (*Populus deltoides*), which is now quite extensively planted, is one of the most rapidly growing species, and is a valuable tree for producing quick effects. The Carolina poplar is especially useful to fill in between trees of slow growth but of more desirable types. Good avenues of this species may be seen about Boston in the metropolitan park system, where the trees have been cut back to form a compact head. This tree, however, is subject to various troubles, and is short lived. Two other native species of poplar, *i.e.*, *P. grandidentata* and *P. tremuloides*, are common, but have no value for planting.

Black or Italian Poplar (*Populus nigra*). — This species has been planted somewhat as a lawn and avenue tree. It grows even more rapidly than the Carolina poplar, and possesses similar characteristics. It is affected by a rust (*Melampsora populina*) which sometimes causes much defoliation.

Lombardy Poplar (*P. nigra* var. *italica*) has been planted sparingly for more than a century in New England, and has come into wider use of late. It is used somewhat on narrow avenues, although on account of its ascending and close-branching habit of growth it does not furnish much shade, and is, moreover, too stiff and conventional in appearance for most places. The white or silver-leaved poplar (*P. alba*) and the

balm of Gilead (*P. candicans*) have been planted occasionally on streets and near dwellings for many years. The former, which is characterized by its silvery leaves, grows to a large, widespreading tree.

Black Locust (*Robinia pseudacacia*). — The black locust is one of our most rapidly growing trees, and while it is spontaneous here it is native farther south than New England. It adapts itself to severe conditions, and withstands obnoxious atmospheric gases better than any other tree, but it is so attacked by borers at times as to render its use as a street tree of little account. It is a valuable honey tree, and may be employed as a hedgerow or screen near dwellings, and near smelters and large manufacturing plants where noxious gases prevail.

Honey Locust (*Gleditschia triacanthos*) is a tree reaching large dimensions and provided with stout thorns. It is sometimes used in planting.

Chestnut (*Castanea dentata*) frequently grows profusely along roadsides and at times on lawns. It is not adapted to street planting on account of the litter accompanying fruiting, and its rapid destruction from the blight at present renders this species useless for any purpose.

Hackberry (*Celtis occidentalis*), which is closely related to our elm, is found sparingly in some of our river valleys, and occasionally met with on streets side by side with the elm. During recent years some have advised planting this tree instead of the elm, as it is said to be less susceptible to insects, particularly the elm-leaf beetle. It is a much inferior tree, however, to the elm.

Hardy Catalpa (*Catalpa speciosa*) is more at home in the west, although used here as an ornamental tree. With us it does not sustain its western reputation for growth, and according to our observations it has little or no value as a street tree in most northern sections.

Some of the willows are employed effectively for planting near marshes and low, swampy grounds. They afford protection to roadsides and are valuable as screens to unsightly places. The laurel-leaved or bay willow (*Salix pentandra*), which attains a height of 20 or 25 feet, is used on country roadsides and sometimes on lawns. It has dark green, glossy foliage. It is adapted to hedges and thrives well near the seashore. The weeping willow (*Salix babylonica*) and a few other forms are planted for ornamentation and shade-producing effects.

Fine individual specimens of the black walnut (*Juglans nigra*), a tree sparingly native in New England, may be seen on lawns, but according to our observations on the results of planting this species on roadsides it appears to be a failure as a shade tree.

Box elder (*Negundo aceroides*) is occasionally grown near dwellings, but is not a satisfactory street tree under New England conditions.

The various conifers may be used under suitable conditions, such as on country roadsides, and some use is made of them for this purpose. The white pine and Norway spruce are sometimes planted along roadsides, and are especially valuable as wind breaks. The European larch, Scotch and Austrian pines, as well as our superior red pine, may be em-

ployed advantageously for the same purpose. The shade produced by roadside planting is beneficial to a roadbed, as it prevents the rapid evaporation of water from the surface, and has a similar effect in this respect to some chemical road dressings in controlling dust. Moreover, a roadbed under such conditions retains its surface better than one constantly exposed to the sun, and there is less trouble from drifting snow.

Since new plant material is being constantly introduced into the United States from foreign countries there is a likelihood of some new and desirable species of shade trees becoming available in the future.

FIG. 8. — Street with ideal tree belt. (See Fig. 13.)

The large and unrivaled collection of trees to be seen in the Arnold Arboretum, Jamaica Plain, Mass., furnishes good examples for consideration. According to the most experienced planters the trees best suited for street purposes in New England are as follows: *elm, rock, white, red* and *Norway maples, red, scarlet* and *pin oaks, basswood, tulip tree, Ginkgo, cucumber tree, hackberry, English elm, horse-chestnut, sycamore* and *white ash.*

For wide avenues large species such as the *elm, rock* and *white maples, tulip tree, sycamore,* etc., are recommended; and for narrow streets the *pin oak, Norway maple, sweet gum, catalpa, Ginkgo* and *horse-chestnut.* For severe conditions the *English elm, horse-chestnut, linden* and *Ailanthus* are considered the most desirable species. No fixed rule, however, can be laid down as regards the use of the different species of trees for wide, medium or narrow streets, as different effects in planting are often sought. Indeed, one of the most serious defects in planting of all kinds is the lack of originality. Imitation in methods, the constant use of certain species and varieties, and the extreme conventional effects often produced become wearisome, while the marked diversity of Nature's planting, always resourceful in producing harmonious effects, never becomes tiresome. In general, however, the large type of shade tree, like the elm, maple and others, should be used on wide streets, and those having a more pyram-

idal type of crown are better suited for narrow avenues. In considering the problem of the selection of shade trees it should be borne in mind that there exists much variation in their habit of growth due to the conditions under which they are grown, and what may do well in one location will be more or less of a failure in another. There exists a marked variation in the growth of trees, even of the same species, in a restricted territory, and one can find much variation in their mode of development, such as habit of branching, size and color of leaves, height to which they grow, and age to which they attain, — in short, their general configuration. The elm grows quite differently in the north than in the south, and even in New England many specific types may be met which are characteristic of special localities. Hence, in order to secure the best type of elm trees for planting it would be well worth while to obtain them from localities which develop the best branching habits, such, for example, as the Berkshire region in Massachusetts. There are some species that are indigenous to the south which grow larger and do better in their native environment than in the north.

Such trees as the magnolia, catalpa, Kentucky coffee tree, box elder, persimmon and mock orange are much better adapted to the south than the north, and consequently are of much more value as ornamental trees in that section.

What shall we plant?

Perhaps the most perplexing question relating to shade trees, at least during the last decade, is "What shall we plant?" There has probably never been a period within the memory of living man during which such severe conditions for vegetation have prevailed, especially in the eastern States, as in the past few years. Meteorological records for many years back would undoubtedly fail to show similar conditions, and even if they did they would be of little value, owing to the fact that there are important factors other than those recorded by meteorological observations which greatly affect vegetation and its mode of development. The growth of trees themselves, as well as local variations in a restricted environment, constitute a record of general meteorological phenomena. Since trees live a century or more, these data are valuable.

Fig. 9. — Showing deterioration of elms, largely due to the leopard moth.

Considering the amount of deterioration in trees during recent years many tree wardens and city foresters have been in a quandary as to what species to plant. But there is reason to believe that these severe conditions are past, and it may be a century before they occur again. One of our most valuable and beautiful species, *i.e.*, the elm, has been practically abandoned as a shade tree in some places owing to its rapid and general deterioration. There are many other species that have been affected in a similar manner to the elm, although perhaps not so seriously. Notwithstanding the fact that some trees have suffered particularly from various causes, we believe that these should still be utilized for planting, their æsthetic and other qualifications being such that they cannot be dispensed with. Moreover, affection by insects and fungous diseases must not always be considered too seriously in judging the value of a species, since control of many of them is possible with the use of modern methods. It should be borne in mind that many of the pests are secondary or are subservient to other causes.

The European cut-leaf birch, which has been dying off in wholesale fashion of late, is always associated with borers, which are considered a specific cause of the dying of this tree. Quite the reverse is true, however, as the borers are secondary to drought injury. In fact, every serious drought period affects the cut-leaf birch in this manner; the roots become dried out and the tree falls a prey to borers. Borers in trees may not always occur secondarily to some other cause, but it is extremely rare to find healthy trees affected with borers. As soon as a tree becomes slightly abnormal from any cause, infection follows. Even the slightest poisoning from gas or injury to the roots by drought or winterkilling is sufficient cause for weakening the trees, and borers and other insects follow as a secondary cause. There is no reason, however, why the European cut-leaf birch or other trees should fall a prey to borers if properly planted in a suitable soil and well supplied with water during drought periods, preferably by subirrigation methods.

The elm has suffered from elm-leaf beetle to some extent, although rarely is one found dying from this cause. Many elms have been practically ruined by the leopard moth. However, it can be stated as a general principle that weak trees, or those that are under more or less abnormal conditions, are more likely to be affected by insects and fungi than strong, healthy, vigorous ones. In our opinion this holds true for the elm-leaf beetle infestation, and some of our most careful observers regard the leopard moth as secondary to other causes. The so-called "chestnut blight" is held by some competent pathologists to be secondary to some other cause or deteriorating factors common to the chestnut. In support of this idea it is known that numerous chestnut trees have been dying the last few years, from New England to Tennessee, which are not and never have been affected with the blight fungus.

The most important lesson to be learned from the behavior of shade trees during the past years of trying experience is that we must give more

attention to the specific requirements of the different species of shade trees, particularly as regards soil conditions. Species which cannot tolerate drought or the slightest soil desiccation should never be planted in sandy or gravelly soils possessing little water-retaining capacity; hence care should be taken in dry situations in eliminating those species which naturally grow in wet places. Neither should species that are adapted to dry soil be planted in wet places. The more extensive use of loam or soil containing a considerable amount of organic matter is needed in tree planting.

In conclusion it may be stated that the problems associated with tree planting during the last decade do not constitute a reliable criterion of the specific value of any species, since the same combination of conditions is not likely to occur in a century. We believe, therefore, that any one is justified in planting the much condemned elm, at least in country towns, where atmospheric conditions are much more favorable than in cities, and where the leopard moth is not so destructive.

Rapidity of Growth of Trees.

The variation in the growth of trees, due to the influence of many different factors, is quite marked, and even when trees of the same age are growing side by side great difference in the size and development are noticeable. A chestnut tree under certain conditions will attain a diameter of 3 feet in fifty-six years, while another may require one hundred and fifty years to reach a diameter of 18 inches. The average diameter of 20 white ash trees measured by us was 16 inches in twenty years; and Italian poplars will occasionally grow 26 inches in the same length of time. The Carolina poplar will reach a diameter of 30 inches in fifteen years, which almost equals the growth of the eucalyptus in California. We have observed pin oaks that grew 18 inches in diameter in twenty years. The average diameter of 16 elm trees thirty years old was 17 inches. In another instance a similar number of elm trees attained an average diameter of 20 inches 4 feet from the ground in forty years. Recent measurements have shown that the average diameter growth of the thirty-year-old elm trees for a period of seven years was 3 inches, while that of the forty-year-old trees during the same period was 4½ inches. It is not uncommon to find elms that have grown 3 feet in diameter in fifty years, or 4 feet in seventy years. An elm one hundred and thirty-one years old had a height of 110 feet, and a diameter of 6 feet at the base. On the other hand, many instances might be mentioned where trees have made very slow growth. Some elms, for example, showed a growth of only 11 inches in diameter in fifty years, and a white oak one hundred and thirty-two years old reached a diameter of 16 inches. Rock maples grow fairly rapidly in good soils, but we know of instances in which they have made only 6 or 8 inches growth in diameter in sixty years. Species accustomed to swamps, such as the white cedar and black spruce, grow quite

slowly, the latter not growing more than 5 inches in diameter in seventy years.

To obtain the approximate growth of trees in any particular locality would require measurements of a very large number of specimens. The age of trees may be obtained by counting the annual rings of felled trees, or by cores taken from the trunk of living trees, while the age of conifers and others may be estimated by the number of internodes formed. There is often a wide difference of opinion as regards the age of living trees, as the total leaf area is seldom taken into consideration. Since trees acquire

FIG. 10.—Grand period of growth (cross-section measurements) of an elm tree (*Ulmus americana* L.) in centimeters and decades. The maximum growth occurred between the tenth and thirtieth years, followed by a gradual decrease. From the nature of the curve we may conclude that if the tree had survived under normal conditions it was capable of developing for one hundred years more.

practically all their structural material from the air by means of the chemical processes going on in the leaves, it follows that those possessing a large total leaf area grow much faster than those with a smaller leaf area. A well-branched tree in the open will, therefore, grow six times as fast as one in the forest under crowded conditions. Consequently there is likely to occur much misconception regarding the age of living trees on account of the marked variation in their rate of growth under different conditions. The white pine, according to historical tradition, developed 6 feet in diameter and 250 feet in height in the New England primeval forest, and elms as street trees are known to have lived two hundred years. There are instances in Massachusetts where elms have lived to be three hundred years old. Many shade trees live to be one hundred and fifty years old and even more, and this age is not uncommon for forest

trees. Trees, however, do not grow with the same uniformity throughout their period of existence. At first they start in to grow more or less slowly, which is generally followed between the tenth and thirtieth year by the

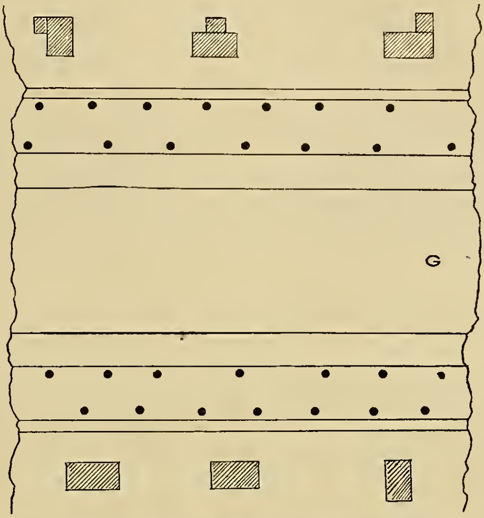


FIG. 11. — Plan of street at Hadley, Mass., approximately 300 feet wide, provided with two driveways with green (G) in center and generous tree belts.

maximum development, this being followed throughout the remaining cycle by a gradual diminution in growth. (See Fig. 10.)

The following list, showing the average growth of trees, represents approximately what a 3-inch sapling will develop into in twenty years.

	Inches.		Inches.
White maple,	21	Yellow locust,	14
American elm,	19	Hard maple,	13
Sycamore,	18	Horse-chestnut,	13
Tulip tree,	18	Honey locust,	13
Basswood,	17	Red oak,	13
Catalpa (*speciosa*),	16	Pin oak,	13
Red maple,	16	Scarlet oak,	13
Ailanthus,	16	White ash,	12
Cucumber tree,	15	White oak,	11
Chestnut,	14	Hackberry,	10

Streets and Avenues.

The modern city streets are, as a rule, much better laid out for tree planting than the older ones, although there are some exceptions to this. In the Connecticut valley, where there is considerable level land, the early settlers showed remarkable judgment and taste in laying out their

towns. Many of these old towns are arranged with exceptionally wide streets that from early times were systematically planted with shade trees. Some of these streets are 300 feet wide and have two rows of shade trees on either side of the street. On the other hand, many towns are poorly laid out, with no proper provision, or at any rate very poor provision, for planting trees.

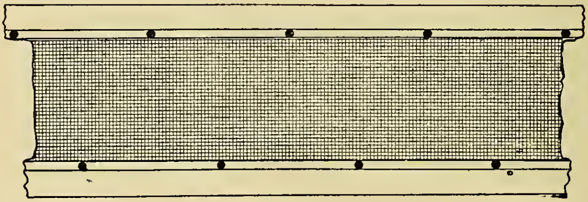


FIG. 12.—Narrow avenue, showing trees planted alternately about 45 feet apart.

Most towns will not accept a highway under 40 feet wide, which is narrow enough for tree planting; in fact, it would be much better if towns would not accept avenues less than 50 or 60 feet in width. Some of our modern cities, when laying out avenues, now make provision for a tree

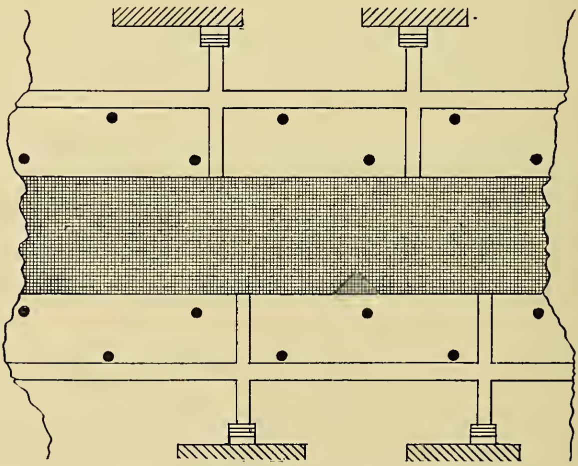


FIG. 13.—Plan of modern avenue provided with a 40-foot roadbed, 6-foot sidewalks, 23-foot tree belts, with alternating rows of trees 60 feet apart.

belt or a space between the curbing and the sidewalk where trees may be planted. This space should be at least 4 feet wide, and 20 or even 30 feet wide is better. A tree belt 2 or 3 feet wide is far better than none, since this allows some space for planting. In case the sidewalk comes next to the curbing, and a special tree belt is lacking, it is always advis-

able to plant the trees near the abutter's line to protect them from horses, etc.; besides, the conditions for development are better here. When trees are planted too close to the sidewalk and curbing the roots interfere with them, and if the tree belt is narrow the roots are continually injuring the walks. In no case is it advisable to plant trees in the ditch, or even so close to the roadbeds that they are likely to be constantly scarred. Wide tree belts make it possible to alternate two rows of trees and secure more massive effects. A street having wide tree belts provided with good soil furnishes an excellent opportunity for tree growth and development, and with the installation of the best modern gas lines, sewer conduits, etc., there is no reason why trees should not flourish under these conditions. When the streets are narrow it is desirable, if conditions will permit, to plant alternately. This system allows much better opportunity for development of the trees.

Besides the tree belt, many of our modern cities reserve a space in the center of the street for a miniature parkway, to furnish a chance for the planting of trees and shrubs.

Much more attention should be given at the present day to the laying out of streets, and towns should be more careful about accepting too narrow highways. The present generation might learn much concerning street planning from the early settlers of our New England towns.

Distance to plant.

Opinions naturally differ in regard to the distance apart to plant trees. In fact, we must expect to find a diversity of opinion in all matters relating to the care and treatment of trees and shrubs owing to the vari-

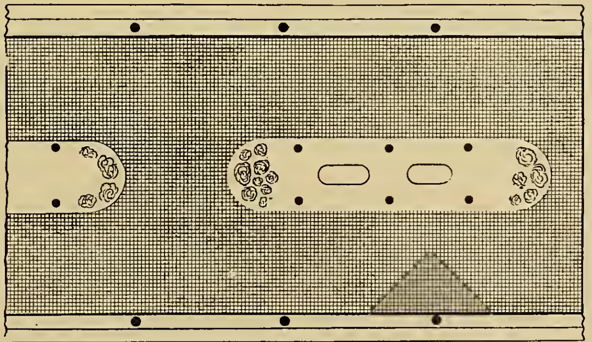


Fig. 14. — Plan of street with parkway and 6-foot tree belt.

able conditions under which they grow; neither are the results sought for always the same.

If street trees are to be planted for their final individual effect they should be set far enough apart not to interfere with one another; but if

the effect of the avenue as a whole is aimed at they can be planted closer together. What holds true in regard to trees is also true of shrubbery. Some gardeners plant masses of shrubbery together to get the effect of the whole, while others plant for the individual effects. Trees planted 20 or 25 feet apart will interfere in a few years, and if allowed to remain at this distance the individual effect of the tree is destroyed, although such close planting on an avenue is often effective.

In one city which we recall the elms were planted 25 to 30 feet apart many years ago, presumably with the intention of future thinning, but as no one apparently ever had the courage to do this, the trees have now so developed as to interfere, and as a result have become deformed through crowding. It is now too late to practice thinning on these streets. While their individual characteristics are destroyed by their restricted development, yet it must be confessed that the high Gothic arch effect produced by such close planting is effective.

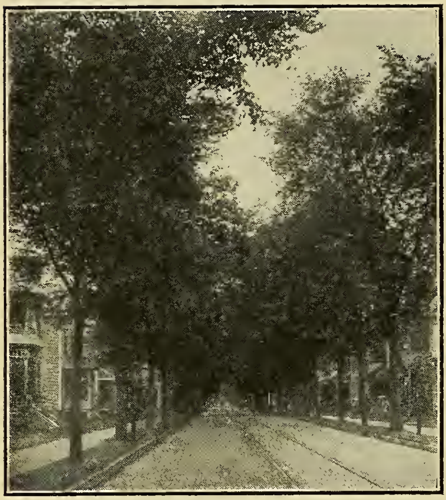


FIG. 15. — Street with tree belt, showing close planting.

When trees are planted very closely, every other one can eventually be taken out. The principal difficulty with this method is the courage required to do it; besides, in most places a hearing would have to be given for their removal which might meet with strong opposition. In one instance ash trees were planted in a row 25 feet apart. The limbs touched in twenty years, and later every other tree was removed, leaving the trees 50 feet apart. At their present rate of growth it will be some years before they interfere with one another.

The limbs of medium-sized rock maples planted 40 feet apart will interfere, as will those of larger trees of this species when planted 60 feet apart. A good average distance for planting most street trees, however, is 45 to 55 feet. Even 70 to 80 feet is not too far apart to plant elms in some localities, as this tree grows to a large size, with a wide spread of foliage, and we are familiar with specimens of rock maples growing along a roadside which have a spread of 75 feet. For smaller trees, such as the European linden, 30 feet apart is not bad. Many maples are set 50 feet apart, and in localities where the development is slow and they do not attain a large size, even 40 feet apart is suitable. When the growth

of permanently planted species is slow, alternating trees of quick growth, like the Italian and Carolina poplars, is advisable, and when the more permanent trees have reached a fair height the poplars may be removed.

Country Roadsides.

One of the wisest provisions of the Massachusetts laws relative to shade trees is that trees and shrubs bordering country roadsides shall be protected by statutes similar to those in residential districts. Much of the senseless slashing of roadside shrubbery so long in vogue is now largely prevented. New England country roadsides are unsurpassed in beauty, and the miscellaneous character of trees and shrubs to be found growing along them is a source of great pleasure to tourists.

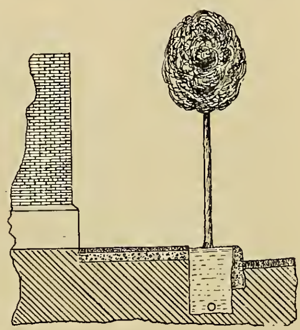


Fig. 16. — Illustrating method of growing trees on busy thoroughfares. The conventional type, such as the Oriental plane which tolerates severe annual pruning, is planted between the sidewalk and curbing in a rich loam 3 or 4 feet deep, provided with special subirrigation tile.

There are several ways of treating country roadsides. One of these methods is to maintain a regularly planted tree belt on a graded and neatly kept roadside, which results in a conventional effect. Another scheme consists in allowing the development of shrubbery and eliminating the tree growth which is often objectionable when crops are growing up to the highway. Or a system combining both shrubbery and trees may be employed, allowing the trees eventually to crowd out most of the shrubbery.

Most roadsides are lined with a miscellaneous growth of shrubbery and trees, located irregularly, which produce good effects, but when conventionality in the surroundings has been aimed at the well-kept roadside and tree belt are legitimate. However, there are roadsides on which no trees or shrubbery can be allowed, — for instance when the road runs through valuable farm land used for more or less intensive agricultural purposes. Trees absorb a great deal of moisture, and this factor and the shade produced interfere greatly with crop production.

For generations roadsides have been used for dumping grounds by certain misguided persons, and one of the objects of maintaining roadside shrubbery in its natural condition is to cover this extreme unsightliness from view. Unfortunately many think they are conferring a benefit on the public when they cut roadside shrubbery and leave it beside the road to decay. Roadside planting is Nature's planting, and is envied by the best landscape architects. It has the merit of intrinsic beauty; it is harmonious, no matter how heterogeneous the mass may be, and never becomes tiresome or monotonous like conventional planting. Many

of the shrubs and vines which decorate roadsides are now used extensively by landscape gardeners in planting, and various species are very highly prized.

The native shrubbery consists of the various elderberries, Viburnums, honeysuckles, cornels or dogwoods, hawthorns, hollies, sumachs, azaleas, laurels, blueberries, etc. There are also such species as the chokecherries, witch-hazel, sassafras, alders, etc.

FIG. 17. — Country roadside, showing spontaneous growth of native species.

The most characteristic New England country roadside trees are the chestnut, various oaks and maples, hickories, ashes, pines, hemlock, elm, cherries, hornbeam, tupelo, birches and poplars. They are found growing in all sorts of combinations, mingled with different types of shrubbery, vines and herbaceous plants, with resulting effects quite unlike those obtained by artificial planting. Aside from the removal of briers and other growths too close to the roadbed, or the cutting out of the natural vegetation near abrupt curves where its presence constitutes an element of danger to traffic, or in cases where some legitimate scheme involving permanent improvement is concerned, roadside shrubbery should not be destroyed. There are, of course, occasions when the cutting of roadside shrubbery is desirable to improve the new growth which soon follows, but this should be done with discretion and care.

Root Characteristics.

There are well-defined differences in the development of the root systems of shade trees. All seedlings develop what are termed primary and secondary root systems; the former are known as taproots and the latter as laterals. In certain species like the red cedar the taproot develops quite extensively. In young trees its function is relatively more important than in older ones; hence it is usually easier to transplant large pasture cedars than small ones, which are more dependent on the taproot.

The lateral root system in some trees is well developed, and those having this system are in general the easiest to handle. The elm, maple,

hemlock, pine and others are easily transplanted with little loss because it is not difficult to obtain enough of the lateral root system to supply the tree. Some species, however, possessing lateral root systems appear to be dependent upon root fungi (*micorhiza*), which restricts them to particular soils and renders them sometimes difficult to get established in certain localities. Many plants, like the sumach and others, possess long, creeping lateral roots which must be taken up carefully to insure successful transplanting.

Depth of Roots.

Some idea of the depth to which roots extend may be had by examining excavations near trees, and also to some extent by plowing. Most elm and maple roots are confined within 2 feet of the surface, but in wet soil they are generally much nearer than this. The large roots of the European larch are very near the surface, and usually somewhat exposed. Pine and hemlock roots are frequently seen running on top of the ground, and in swamps, where trees often blow over, it may be observed that the entire root system is located within a few inches of the surface. Oak and chestnut roots do not appear to penetrate very far, as shown by the ease with which winds uproot the trees when growing even in ordinary soil. The maximum number of roots of most trees in ordinary soil is probably located between 1 foot and 18 inches below the surface.

Roots often penetrate soil to great depths, and when growing in gravel become flattened out in irregular shapes from growing around large pebbles. Apple tree roots have been known to grow through a mass of coarse gravel 8 feet to obtain water, and elm and rock maple roots will penetrate quite a distance to reach a water table. The roots of the common clover one year old have been known to descend to a depth of 8 feet; those of parsnip more than $13\frac{1}{2}$ feet; and of lucerne, a leguminous plant, more than 20 feet. The roots of a leguminous tree growing in India have been traced to 69 feet below the surface without reaching their full length.

The distance to which roots extend laterally may generally be roughly determined by the spread of the crown. Practically all trees extend their roots beyond their foliage or branches. The Norway spruce and others, which have narrow crowns, do not have an extended lateral system. The maple and elm have well-developed root systems which extend to a considerable distance.

There is a correlation between the shape of the aerial portion of a plant and its root system. The leaves of root crops like radish, turnip and others are so placed on the stalk that they divert the rain toward the axis of the plant, or taproot. On the other hand, the apices of the leaves of many plants are deflected away from the axis, *i.e.*, toward the lateral or feeding roots. Most shade trees are noted for their large crowns, with the leaves pointing away from the trunk and directing the rain where it is most needed, whereas the soil near the trunk does not receive much water. This feature admirably illustrates biological adaptation.

Such trees as the balm of Gilead and Italian poplar possess extensive root systems. This is evident from the root suckers which may frequently be seen coming up quite a little distance beyond the spread of the branches, and many roots will grow in a horizontal direction to great distances. There is an authentic case of an elm whose roots were found in abundance 75 feet from the trunk, — just the height of the tree. In another case the roots of an elm were found obstructing drain tile which was 450 feet from the tree. The leading roots of a pear tree developed in 60 feet of a line of drain tile during five years measured 8,498 feet (1.61 miles); if smaller roots be included, the total length was about 2 miles. A squash grown in a greenhouse produced in a few weeks a total of 15 miles of root growth, or over 1,000 feet of roots per day.

Obstruction of Sewer Tile, etc., by the Roots of Trees.

The obstruction of sewer services and drain tile by tree roots has in some places become such a nuisance that steps have been taken in certain cities to obviate it. The elm is a troublesome tree in this respect, often completely filling land drain tile for long distances with roots, and putting the tile out of commission.

The Carolina poplar is a more troublesome tree, however. This causes so much damage to house sewer connections that its use for planting has been discontinued in some sections. The Carolina poplar is a tree of such rapid growth that an extensive root system is developed in a short time. Sewage appears to have an especial attraction for the roots of this tree. They seem to have no difficulty in penetrating even the cement joints of Akron tile, and when once in the tile the root development is remarkable. In one city as many as eighteen sewer services had to be taken up and repaired in one month the sections were so badly congested with roots of the Carolina poplar. Other tree roots occasionally enter tiles, cesspools and wells, but the Carolina poplar appears to be the greatest offender in this respect.

From the results of numerous experiments covering a period of years it is evident that roots can be kept from penetrating drain tile by properly packing the joints with chemically treated fibers, which destroy the delicate roots as they attempt to enter.[1]

Branching Characteristics.

There is considerable difference in the branching habits of trees. This must be understood before a tree can be developed along desirable lines. The red and Norway maples have a habit of sending out large branches or secondary leaders at more or less oblique angles, very close to the ground. If allowed to develop, these render the trees undesirable for street use; but if started right when young by pruning, such trees may be trained to meet the requirements of residential streets. However,

[1] Mass. Agr. Expt. Sta. Rpt. 23, Pt. 2, p. 35 (1911).

if pruning is attempted when they are fairly well developed, great injury results, and the symmetry of the tree may never be entirely regained.

The habit of the rock maple is to produce one or two strong vertical leaders, and its ultimate development is such that it seldom gives much trouble so far as pruning is concerned.

The branches of the pin oak are low and drooping. This objectionable feature detracts from the value of this tree for use on streets, but may be overcome by high pruning.

The branching habits of the elm, on the other hand, make it one of our most desirable shade trees, the branches invariably forming acute angles with one another. Elms oftentimes develop low, more or less horizontal branches, but these possess no permanent value and may subsequently be removed. The ideal mature elm offers no obstacles to street traffic, and even the wires of public service corporations seldom interfere with the branches.

On the other hand, evergreens, like the Norway spruce, branch to the ground, and for their best development they should never be placed where it is necessary to prune them, as cutting the lower limbs of the Norway spruce and most other conifers detracts greatly from the beauty of the trees.

Many trees, including some of the maples, birch, oak, chestnut and elm, and most shrubs, have a habit of suckering or sprouting from the roots. Much of the timber growth such as the chestnut is of this nature, and is termed "sprout growth." This growth is very common in woodlands and along roadsides which have been cut off. Trees originating from root suckers do not possess the value of those grown from seed, and consequently should not be used for transplanting. Stump growth may develop faster for the first few years than seedlings, but later growth is often slow. As the sprout growth reaches maturity it generally becomes involved with the stump, which ultimately decays, leaving an ugly cavity at the base of the tree. Most sprout growth shows abnormalities in the foliage the first few years, and it is likewise more susceptible to aphis. The extensive root system of the tree which nourishes it induces malnutrition or overfeeding characteristics which are pathological.

The formation of sprouts on the trunks and branches of trees is of great value in their restoration. Sprouts sometimes originate from the callus of wounds, and are quite serviceable in accelerating healing.

Soil Conditions, Texture, etc.

It requires only a glance at the trees of any particular region to observe their natural choice of environment. While this does not always mean that trees will not grow elsewhere with the same degree of vigor as in their natural habitat, — indeed the growth is often more vigorous, — they are very likely to prove less resistant to various troubles. One cannot be always certain, however, that, because a species is restricted

to a particular location or habitat, it has realized its optimum condition for development. In some cases there is reason to believe that their choice may be determined by some minor inherent peculiarity common to the species, such as seed habit.

Some species of plants are confined to dry soils, while in other locations the same species grow in moist situations. In a botanical sense these are identical species, but they may possess such different physiological adaptations as to warrant the term "physiological species."

Soil texture plays an important rôle in the distribution and development of plants, and is inseparably associated with water-retaining capacity. Soil texture affects the color, size and thickness of the foliage, and also has an influence upon susceptibility and nonsusceptibility to certain troubles.

Even in limited areas trees possess different habits of growth, and soil texture is probably the most important contributory factor. For example, the elms in the eastern part of Massachusetts are different from those in the Connecticut valley. Those growing in the Housatonic valley differ from either, assuming a more vase-like form and being characterized by the development of a larger number of vertical leaders or branches. The greatest number of symmetrical elms and the best types of branching occur in this region.

The rock maples in the Connecticut valley are of a different type from those found elsewhere, growing larger and more luxuriantly. This region is characterized, also, by the occasional occurrence of a beautiful, dark-colored, densely foliaged form resembling the black maple, *Acer saccharum* var. *nigrum*, noticed farther west. Like the elm, much difference in the branching habits of the rock maple may be observed here and there which appears to be characteristic of certain localities.

There is, however, a wide diversity of conditions in nature under which trees may live and develop. The rock maple, oak and hickory appear to be at home on our rocky hillsides, while the basswood, canoe birch and beech are adapted to soil containing humus. The chestnut is confined largely to clay hills or "drumlins," where it has grown since time immemorial. The sycamore, pin oak, red maple, tupelo and swamp white oak are confined to low, moist soil; while the scarlet, red, white and yellow oaks, pitch pine, poplar, gray birch and red cedar prefer drier locations. The willows, Carolina poplar, red birch and hackberry are closely restricted to streams; and the white cedar, tamarack and black spruce to swamps. The white pine is quite generally distributed, and in New England it is adapted to a greater variety of conditions than any other tree in our flora.

Notwithstanding the wide diversity of conditions to which our native trees are subject, they can with care be made to thrive under different conditions. Rhododendrons may be grown successfully in dry soil having 2 or 3 feet of muck placed underneath, and trees adapted to moist places will develop well in poor soil if freely supplied with fine-textured loam.

The moisture content of a relatively dry soil may be greatly modified by the addition of organic matter, which increases the water-retaining capacity and makes the soil more suitable to swamp-loving species. But swamp trees that make excellent growth in dry soil need to be supplied with water during drought periods.

There are other factors than those of soil texture, water supply, etc., that influence the distribution of plants. The chemical composition of the soil affects the habitat of trees, and is capable of modifying to some extent their mode of growth. Many plants are restricted in their range owing to differences in the chemical composition of the soil. Certain species are practically confined to the seacoast, where the percentage of chlorine in the soil is greater than it is inland; but these species may be grown successfully elsewhere. The amount of humus in the soil affects the growth of trees materially. While 20 or 30 per cent. of organic matter was formerly contained in the upper strata of our soils, now not more than 2 to 5 per cent. may be found in a large portion of it. Organic matter has a vital effect not only on the physical properties of soils, but on their chemical and biological properties, influencing the development of *micorhiza* (beneficial root fungi) that are intimately associated with the roots of some of our shade trees. Soils also contain toxic elements that are often found in sufficient abundance to make it difficult to establish certain species in the desired location.

It is desirable in all cases when planting trees to give them conditions closely approximating their requirements as determined by their natural habitat. Elm trees often grow in swamps, as well as in dry and sandy soils, but both of these habitats produce poor specimens. The swamp tree is usually of inferior shape, and sandy soil as a rule produces a lank, spindling growth, with inferior foliage. Even the best type of elm, if planted under uncongenial conditions, will make poor development regardless of its inherent qualifications. The elm, therefore, should never be planted in dry, gravelly soil without being supplied with a large amount of good loam of the proper texture. The rock maple, on the other hand, will endure a dry soil much better than the elm, although if too dry borers may affect the tree. The scarlet and black oaks will thrive in such a soil.

In general, the texture of the soil in most towns is fairly well suited to the growth of a large variety of trees. The soils often lack organic matter, hence the application of loam is advantageous. On the other hand, some of our New England river valleys are particularly adapted to the growth of elms and maples, and the addition of loam in such cases is not so necessary.

Street trees are too often forced to exist under extremely unfavorable conditions; therefore they require different consideration from those more favorably located. Many city trees are planted in made soil, and some of the refuse found in these fillings is hardly adapted to tree growth. Such soils are, moreover, likely to be deficient in organic matter and plant food, and are often in such poor mechanical condition that the soil capillarity is of little account.

Soil Covers, Lawns, Macadam, etc.

The nature of the soil cover surrounding trees is scarcely less important than that of the soil in which the roots are growing. We find trees growing under many different conditions: *e.g.*, lawns, mowings, cultivated fields, paved and macadamized roads, sidewalks, etc., and it is hardly necessary to point out that cultivation is much superior to all other conditions. The importance of tillage is scarcely appreciated in the case of ordinary crops, even by lifelong farmers. Stirring the soil, even without the use of fertilizers, has enormous influence on the growth of crops, and is also an important factor in the control of various tree pests, a thrifty tree being more resistant to infection. Cultivation not only aerates the soil, but breaks up the capillarity and conserves the moisture, — of great importance in dry soils.

Examples of the good effects of cultivation on shade trees may be seen in the many specimens growing luxuriantly in soil in which crops have been cultivated for years. Trees under these conditions branch freely and produce large leaves of a deep green color. Cultivation of the soil about trees for even one year has a decided effect.

Next to cultivation, lawn conditions are perhaps the best. The grass, which is constantly being mowed and left on the ground, acts as a mulch and conserves the moisture. Some of our best trees grow in pastures, where the conditions are often unfavorable to the growth of grass or where the grass is kept closely cropped by grazing. A mowing or hay field is one of the worst possible locations for a tree, the elm being particularly susceptible to the ill effects of such an environment. Measurements of elms growing on either side of a road, one series being under partial lawn and the other under partial mowing conditions, showed differences in their development. The average growth of these trees during a period of twenty-five years is as follows: those on the lawn side of the road had a circumference of 56 inches, while those on the other, or mowing, side were only 49 inches. In another case the average circumference of lawn trees was 37 inches, and that of the mowing trees, 26 inches. These trees, which had been growing under these conditions for many years, were of the same age, and were so located that the difference in light intensity cannot be considered a factor in their development.

The extensive use of various materials for paving roads can hardly have a beneficial influence on tree growth. In some cities a great many trees are found on streets paved with asphalt from one block front to another, allowing nothing but a small space around the trees unpaved. It is a question in such cases where the trees obtain their moisture, although they exist year after year, and make some growth. No doubt some water is obtained from catch basins and sewers; at any rate, moisture is usually found in the soil under the most impervious substance employed in paving, and during the most severe droughts trees on paved streets often suffer less from lack of water than others apparently more favorably

located. This may possibly be explained by the fact that whatever moisture reaches the soil under these paved streets is to a certain extent conserved, the surface evaporation being less than where no pavements are found. The severity of the conditions to which trees are subjected when surrounded by pavements varies considerably, and when more or less water is allowed to leach through them the soil moisture conditions cannot be unfavorable. The more thoroughly a roadbed is sealed the more soil aeration must be affected. How largely this factor enters into the problem is unknown, but while trees do survive under extremely severe conditions, their length of life must be limited.

Excavations, Curbings and Sidewalks.

Remodeling and regrading streets are a frequent cause of injury to trees. In placing curbstones large roots are often cut, and in regrading streets so much soil is frequently removed that the base of the tree is left high in the air and the exposed root surfaces become injured by traffic. Besides these mechanical injuries, the exposed roots are likely to be injured from other causes such as winterkilling, sun scald, road oil, etc. If the roots are cut to any extent the tree deteriorates in value, and if grown under other unfavorable conditions it usually succumbs to a lingering death. Again, root mutilation too often takes place when sidewalks are being laid, and it is quite difficult to prevent it when the trees are large and have extensive root systems. The cement sidewalk with its deep foundation constitutes more of a menace to roots than a tar or brick walk, but if care is used in excavating, much root cutting may be prevented. The roots of trees located under a modern roadbed have little chance of remaining uninjured, with the sewers, water pipes, gas lines, telephone systems, electric wire and other conduits that are constantly being installed. Electric railways may also cause injury to trees in various ways. It is more injurious, of course, to the tree to cut the large roots close to the trunk than the small ones some distance from it. In widening a certain road a few years ago 4 or 5 feet of the banking adjoining a row of ash trees were removed, destroying a large number of the smaller roots on the west side of the trees, but this cutting had little or no noticeable effect upon the trees. They were young and vigorous, and on the east side the roots extended into cultivated ground, apparently soon making up for the loss on the roadside. Since the cutting of these roots, every other tree has been removed, and measurements of the rings of the stumps show that not the slightest retardation in growth had taken place following the operation. One fact should be remembered: mutilation of the root system is not so serious as that of the stems and branches, the former responding more quickly to the stimulus caused by mutilation. In transplanting young trees 80 to 95 per cent. of the essential part of the root system is usually destroyed, and even with a slight pruning of the top the tree usually survives when the work is properly done. Indeed, the cutting of the roots has been known to be beneficial, as, for instance,

in the case of gas leaks in the street. Many cases are known to the writer where large trees have escaped gas poisoning owing to the fact that when the curbing was put in some of the larger roots leading towards the gas main were destroyed; therefore when leakage occurred there were no roots favorably located to absorb the poisonous substances.

The cutting of roots on vigorous trees is not so serious as cutting those of old trees. In the latter case judgment should be exercised as to root cutting.

Effects of Light and Shade.

Most plants are quite susceptible to light and shade. Those which require light are termed photophilic (light friendly), and those which thrive best in shade, photophobic (light shunning). Shade has an unfavorable effect on plants, causing a spindling growth and rendering them more susceptible to diseases. On the other hand, too much light is detrimental to certain species. The dense shade from street trees interferes at times with the growth of grass and shrubbery on lawns. Since there are relatively few varieties that are adapted to shade, it often becomes a problem as to what to plant in such locations. However, a glance at any native flora will give a hint of what is best adapted to shady places. Such wild species as clethera, rhododendron, hobblebush, leatherwood, moose and mountain maples, laurel and honeysuckle tolerate shade, and there are some exotic shrubs, such as *Ligustrum regeliarum*, *Symphoricarpus vulgaris*, *Xanthorrhiza apiifolia*, etc., and vines like *Euonymus radicans* and *Vinca minor*, that are adapted to shade.

Notwithstanding the fact that shade is natural to some species, they develop a less spindling growth in light. Shade trees require light; hence for their best development they should be planted far enough apart to prevent interference and spindling growth. The effect of shade on trees when growing thickly together is a dying of the lower branches, inducing growth in height at the expense of spread of the crown and growth in diameter.

The variation in light intensity differs, as is well known, during the year. Light intensity is also variable in different localities, and there are definite variations that occur in light intensity during the day which are more pronounced at some seasons of the year than at others. The difference in the amount of sunshine peculiar to any region is not dependent on latitude but on other conditions. For example, the number of hours of total sunshine occurring during the year at Boston, Mass., is 2,493; Cleveland, Ohio, 2,075; Chicago, Ill., 2,616; Milwaukee, Wis., 1,865; Seattle, Wash., 1,973; Elkins, W. Va., 1,737; Phoenix, Ariz., 3,742, and New Orleans, La., 2,378. These marked variations in the number of hours of sunshine show that latitude does not necessarily constitute an important factor in determining light conditions. The amount of possible sunshine, according to the United States meterological observatories, varies from 37 to 84 per cent. Variations in light intensity

or number of hours of sunshine are correlated with growth and development of vegetation, although temperature is very important too.

Morning light is more intense that that of the afternoon, and this difference exerts an influence upon the growth of trees. Measurements of a large number of tree stumps ranging from ninety-five to two hundred and twenty years old showed 17 per cent. more growth of the radii on the east side than on the west, and the radii measurements attained from the stumps of a row of ash trees running north and south were 24 per cent. greater on the east than west side. Two rows of trees bordering either side of a road running approximately east and west showed a difference of 11 per cent. in their circumference growth 4 feet from the ground, during a period of seven or eight years, in favor of the south row. Daily measurements of light made by us for one year showed an average difference of 10 per cent. in favor of morning conditions. Since photosynthesis or carbon assimilation is proportionate to light intensity, and growth is in proportion to photosynthesis, there naturally follows a greater growth on the east than on the west sides of trees, and the same holds true for the east and west slopes of high elevation. The light conditions at high elevations are more intense than low elevations, and the difference may equal 25 per cent. more or less, depending upon the altitude and other conditions.

Light is an important factor in the process of photosynthesis or carbon assimilation in leaves, about 95 per cent. of the structural material of the tree being obtained by this process. Light inhibits growth and stimulates the formation of mechanical and resistant tissue; on the other hand, darkness or lack of light stimulates growth. Light affects the size, color and texture of the foliage, and, in fact, the whole configuration of the organism.

Since morning light conditions are better than those in the afternoon it is well to set trees with their poorest developed sides towards the southeast, as they will become more favorably exposed to light conditions; hence they will develop more rapidly on this side. Moreover, an avenue of trees located on the east and south sides of a road will develop more rapidly than those on the west and north sides, and trees and crops located on the east side of a hill will develop more rapidly than those located on the west side. An east exposure is therefore much better for the rapid development of an orchard than a west exposure, and the same holds true for different crops and shade trees.

Transplanting.

Too little attention is given to the details of transplanting. It is quite essential that soil conditions should be suitable for the growth of the particular species of tree planted, and in the selection of material for planting there is great need of more care. A large amount of poor material is constantly being used, besides which, injudicious use of the knife and pruning shears maims many trees for life. Trees 6 to 8 feet high are usually

too small for street planting, not being so well adapted to street conditions as larger ones ranging from $1\frac{1}{2}$ to 3 or 4 inches in diameter. Moreover, by using larger trees one can obtain a better idea of their future development and configuration.

The life cycles of trees are by no means identical even in the same species. The conditions which a certain species seems to require at one period of its existence are less suitable for another period, especially as regards soil requirements for root development, older trees appearing to tolerate certain conditions better than younger ones. Young trees 5 to 6 feet high will often fail to grow for some years after transplanting under the poor conditions often prevailing on streets, while larger ones will start immediately to grow.

Much more attention should be given to the type of tree transplanted than is generally given. The same species varies greatly in different localities. Lopsided elms should be avoided, and only those selected which possess a habit of growth calculated to produce a desirable type. It is worth while to secure elms from those localities where the most perfect types abound.

FIG. 18. — A State highway specimen of elm worthless for future development.

In localities where much desirable native material exists this can be used to advantage for street planting, and if carefully handled it will prove successful. Native material, or that gathered from the fields, however, is much improved by nursery conditions, and two or three years under such conditions are desirable when utilizing native stock.

Most competent authorities recommend planting a few trees well rather than many poorly, and when one recalls the large amount of poor planting seen around dwellings, and the weak-looking specimens of trees and shrubs, this advice will appear pertinent.

Town funds[1] do not always allow the appropriation of a large sum of money for transplanting trees, and one must do the best he can with the conditions under which he has to labor. Special attention, therefore, should be given to the adaptability of certain species to the conditions at hand, since the cost of extensive preparation and soil modification is too often beyond the funds allowed for this purpose. The advice given by Olmsted Brothers, landscape architects, in one of their reports, regarding the planting of elms, is to the point: —

[1] During the year 1914, 12,498 trees were planted by tree wardens in 58 cities and towns in Massachusetts.

It would be better to prepare tree beds 2 to 3 feet deep and 20 to 30 feet square, filled with good loamy soil where the present ground is dry and sandy gravel, even if the expense of doing so would be so great that only one tree a year could be planted.

Few trees, however, outside of those planted in the Arnold Arboretum and on a few private estates receive any such treatment. It must be borne in mind in planting that shade trees are always under more or less disadvantageous conditions as regards atmosphere and soil. Hence it is of the greatest importance that they should be aided as much as possible, and the time is not far distant when much more specific methods must be employed in the planting of street trees in thickly settled communities. Even at the present time, where ideal conditions are sought much more money is spent in preparation for transplanting than in purchase of the trees. The majority of street trees which are planted are not supplied with loam or placed in holes over 2 or 3 feet wide and 15 inches deep, and some of them are given space only large enough to contain their roots. Loosening up the soil to a considerable depth is very important, as shown by the results of the use of dynamite in the preparation of soil for transplanting. A hole 5 to 6 feet wide by 20 inches deep in any case should be the smallest used, and it should be as much larger as can be afforded.

Fig. 19. — Elm severely cut back when transplanted. This has destroyed its natural symmetry.

When digging up young trees the roots should be preserved as much as possible, and the more earth taken up with the roots the better. The roots should not be exposed to sun and wind, and if possible should be kept covered and moist. For this purpose damp straw, bagging or sphagnum moss may be used.

It is usually the practice to place the best side of the tree toward the north and the poorest toward the south, since the light conditions on the south side are better, and naturally better growth results. It is also advisable to lean a tree toward the direction of the prevailing winds, and if these are strong enough to interfere with the growth of the tree it should be fastened to a strong stake. Trees obtained from the field where they have been growing close together have long, slender shafts and are top-heavy. When such trees are planted in windy situations it is necessary to support them by stakes.

When the ground is prepared for planting, the injured roots should be recut so that healing may take place, and before being covered they

should be properly arranged in the soil. According to good authorities trees should never be planted more than two or three inches deeper than they originally grew, and too deep planting often causes their death. It is more convenient for two men to set out a tree than one, as one can hold the tree in the proper position while the other is filling the soil in around the roots.

The top soil, if of good quality, may be used, but it is better to discard the poorer subsoil and replace it with loam. Much depends, however, upon the nature of the subsoil and whether the species is adapted to grow in it. In any planting the best soil should be placed at the bottom of the hole or under the roots, and the sod when properly pulverized may be used, care being taken not to interfere too much with the soil capillarity. The poorer soil which covers the roots may be enriched and its texture improved by working in manure or other organic matter. Manure, however, should be sparingly used and thoroughly incorporated with the loam, care being taken not to bring it in too close contact with the roots. Towns and cities which do much transplanting might make good use of composted street cleanings; and if land were available for a small nursery, it could be used to good advantage by tree wardens and foresters.

When a tree is being set out the soil about the roots should be well tamped. Many people apply water to the roots at the time of transplanting, and if the season is an unusually dry one the watering may be repeated occasionally. But persistent watering is injurious, and young trees are sometimes killed in this way. If the soil around the roots is well tamped when the trees are set out it is not essential that water should be applied at all, and it may even be injurious by washing the soil from the roots and leaving air spaces. One of the most essential features in transplanting is to secure as nearly as possible normal conditions of the soil about the roots. It may be mentioned here that watering large trees near their trunks is not a wise practice, since the feeding roots are quite a distance from the tree. One would suppose that an elementary knowledge of tree growth would discourage such a course, although it is possible, by constant watering and cultivation, to encourage the formation of roots at the base of the tree.

After the tree is set out a mulching of hay, straw or horse manure containing considerable straw may be used to help conserve the moisture in the soil and to keep down the grass and weeds which rob the soil of its moisture and food.

Transplanted trees require a certain amount of pruning to accommodate the leaf and root systems to each other, and it is usually necessary to cut back the branches to meet these requirements. (See Pruning.)

There are differences of opinion in regard to methods of transplanting trees, and undoubtedly more than one method may be used. Opinions also differ in regard to the best time of year for transplanting, but it may be said that most persons prefer the spring to the fall. We are of the opinion that it is not advisable to plant too small trees, preferring elms

and maples 2½ to 4 or 6 inches in diameter, since they take hold of the soil better.

At the present day many very large trees and shrubs are being transplanted successfully. Special machines have been designed for use in this work. The Hicks Tree Mover, designed by Mr. Isaac Hicks of Westbury Station, Nassau County, N. Y., is extensively used, and Mr. Hicks has achieved remarkable results in handling very large specimens of trees and shrubs. These tree movers are expensive, however, and for trees 6 to 10 inches in diameter a pair of high, heavy truck wheels, with some simple improvised arrangement, may be adapted. At the present time many individuals are willing to pay a good price for large trees, for which tree movers are admirably adapted and should be more extensively used.

A general tendency has been to plant street trees rather closely, with the idea in some cases of cutting every other one when it should become necessary. The courage to do this when the time comes is often unfortunately lacking, however, and the trees are allowed to grow and crowd one another until it becomes too late to thin them out.

The loss from transplanting need not be great, although there is a great deal of difference regarding species in this respect. During a normal season the loss from transplanting need not exceed 2 or 3 per cent., and sometimes 100 trees from 100 will live. During severe drought periods a greater loss is expected, and even 50 per cent. loss in a good season occasionally occurs from poor planting. Such trees as the tulip tree and tupelo are naturally difficult to transplant with success, and a considerable loss with such species is anticipated.

Tree Surgery.

The term "tree surgery" is a legitimate one to use in describing modern methods of treating trees, as they are similar to those used in human and animal surgery, *i.e.*, the treatment of trees is based upon aseptic and antiseptic methods.[1] In the same manner that modern surgery is successful in correcting deformities, performing operations, etc., so a young and vigorous, although often imperfect, tree may be improved and rendered more valuable by the use of the same methods. While old and decrepit trees are often treated to extend their period of usefulness, it should be borne in mind that it is more desirable to care for the younger, more promising trees, and it is only too apparent that if more attention had been given to the care of old trees at the proper time they would never be in the condition in which we often find them.

Unlike the surgeon, who has no choice of subjects, the tree expert can select his individuals at the start and eliminate the imperfect specimens,

[1] Some prefer the term "tree repair work" to that of "tree surgery" on the ground that the work is of a much cruder type than that generally recognized as "surgery." There are, however, many instances where as much skill and knowledge are required in this work as in animal surgery.

although in the process of development trees need constant attention. It is desirable that antiseptic methods of treatment following pruning, mechanical injuries, etc., shall be adopted.

Pruning.

Besides the necessary pruning at the time of transplanting, the removal of dangerous dead wood and branches every two or three years is essential. In the case of street trees the lower branches frequently need removing or lightening up. When limbs are so close as to interfere, thinning out is necessary to prevent their injuring one another; but this thinning may be overdone so as to affect the beauty of the tree. Some make a practice of thinning and shaping trees when young, thus preventing too much thinning when the tree reaches maturity. The amount of dead wood annually produced in trees is quite large, and it costs about as much to dispose of it as it does to prune it away.

FIG. 20. — Specimen showing poor pruning. Note the long stubs.

In towns a distance of 10 or 12 feet or more may be left between the roadway and the lowest limbs, but in cities the nature and amount of traffic necessitate higher pruning. When street trees are growing close together high pruning is often necessary in order to let in sufficient sunlight, and when different types of trees are planted together, such as maples and elms, the pruning is often high in order that the high canopy or Gothic arch effect formed by the elm trees may not be destroyed. If a more or less symmetrical type in individual specimens is desired, the removal of certain limbs often changes the contour of the trees. We do not believe it desirable to prune the feathery growths often found on the trunks of elms, as they are apparently protective in nature; moreover, in our opinion they add to the beauty of the tree, taking away much of its conventional appearance.

As a rule, the limbs of vigorous maple trees will droop a foot or more a year owing to their increased weight, and in a short time they become too low. Limbs over a sidewalk may be left lower than over roadways. During rain and sleet storms limbs are heavily weighted and often give trouble when too near the ground.

On country roadsides pruning should be high enough so that the limbs will not interfere with hay and wood traffic. All limbs should be cut as close as possible to the tree, and cuts over $1\frac{1}{2}$ to 2 inches in diameter

should be treated antiseptically to prevent decay. Strictly horizontal cuts should never be left. They retain water so that rot is likely to result, and

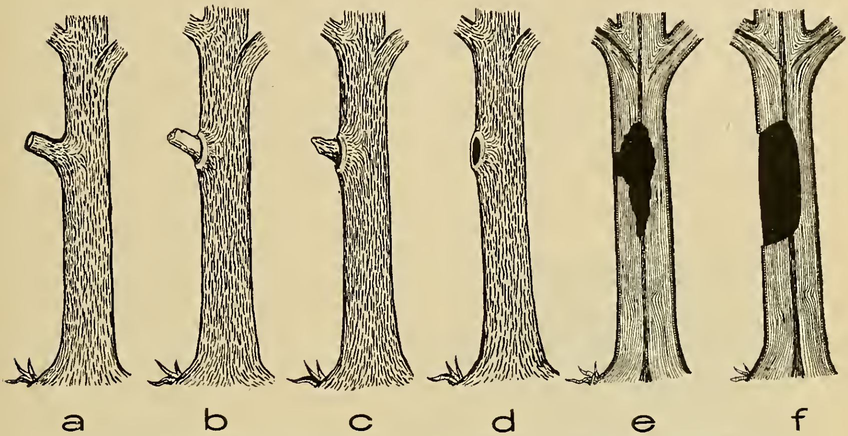


FIG. 21. — Showing the evolution of a cavity and method of treating it: (*a*) long stub left from pruning; (*b*) beginning of decay; (*c*) more advanced stage; (*d*) cavity formed in the wood; (*e*) longitudinal section of the trunk showing cavity; (*f*) cavity cleaned out and ready for orifice covering.

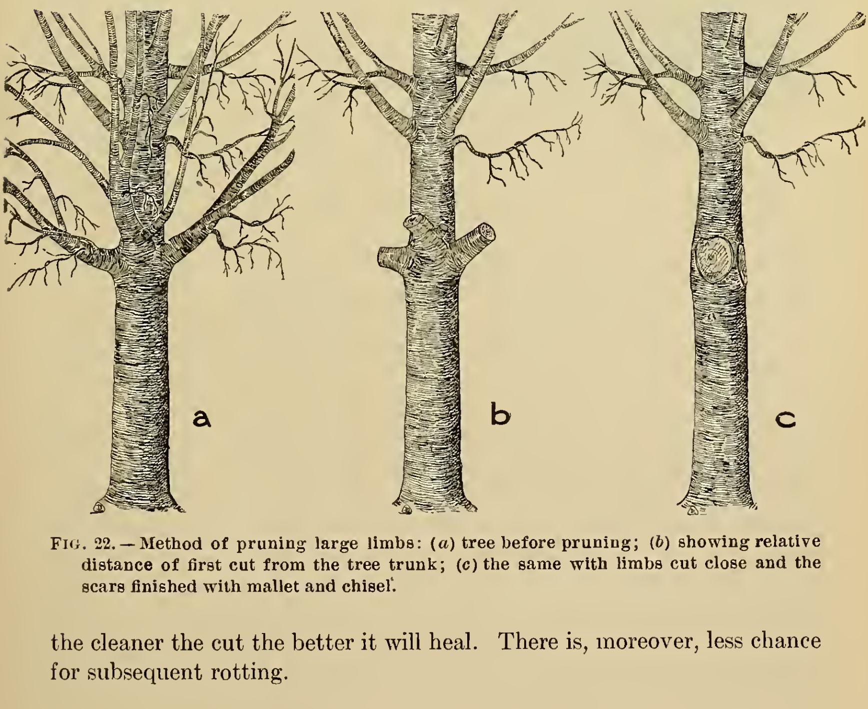


FIG. 22. — Method of pruning large limbs: (*a*) tree before pruning; (*b*) showing relative distance of first cut from the tree trunk; (*c*) the same with limbs cut close and the scars finished with mallet and chisel.

the cleaner the cut the better it will heal. There is, moreover, less chance for subsequent rotting.

Many of the cavities in trees are caused by leaving long stubs on the trunk of the tree, which become infected and disintegrated, the decay following back into the heart of the tree. (See Fig. 21.) It is therefore essential that close pruning and antiseptic treatment of the wounds should be practiced in order to prevent this decay. The plastic materials in a tree will not follow up a long stump and form a callus unless there are some branches left upon it which bear leaves, and even then healing is most likely to take place only close to the living branch of the stump.

Two or more cuts should be made when pruning practically all limbs to prevent peeling, and on limbs of any size it is necessary to make the incision on the under side for the same reason. (See Fig. 22.) After removing the limbs with a saw, a mallet and chisel may be used to smooth up the cut surface. This induces a better callus growth. It is well to prune carefully at the time of transplanting, when all street trees should be trimmed to a height of 8 or 10 feet or more. It is usually necessary at this time to prune for the purpose of balancing the root and branch system, and when this is done some of the less desirable branches may be sacrificed, and those remaining may be cut back to some extent, if necessary. However, a great deal of unwise and careless pruning of nursery stock and young trees is done, and many specimens are ruined in this way. Tree pruning shears should not be used in a haphazard manner, and a distinct idea of the object in view should be borne in mind. Moreover, species differ greatly in their response to mutilation, and what may prove of little consequence to one may be quite injurious to another.

FIG. 23. — Formation of a cavity in tree caused by the removal of a large limb, and wound not properly cared for.

The practice of topping trees is injurious, and should never be resorted to except in special cases. All of the reserve material in the tree is stored in the roots, stem and branches, and in a transplanted tree this is sufficient to develop the foliage. It is necessary that a young transplanted tree should have a certain amount of foliage for growth and development, since the rapidity of growth is dependent upon leaf development.

The type of trees termed "bean poles," having the tops so cut away that there are no limbs left, is not suited, therefore, to transplanting. Trees like the willow will survive any amount of mutilation, but elms, maples and others must be handled more carefully to obtain the best results. Pruning has a marked effect on the conformation of trees. Pruning the branches or secondary organs directs the energies of growth to the trunk, whereas topping, or the destruction of the leader, has the

reverse effect. Continual pruning of the lower branches induces the tree to grow taller than it otherwise would, and in some locations is advantageous to the tree. Topping is destructive to the formation of typical crowns in such trees as the elm, hornbeam, etc., whereas in other trees, like the Carolina poplar, topping or pollarding has a tendency to thicken them up and make them more desirable shade trees. The configuration of the crowns of maple trees is modified to some extent by topping them when they are young. This modification is manifested by

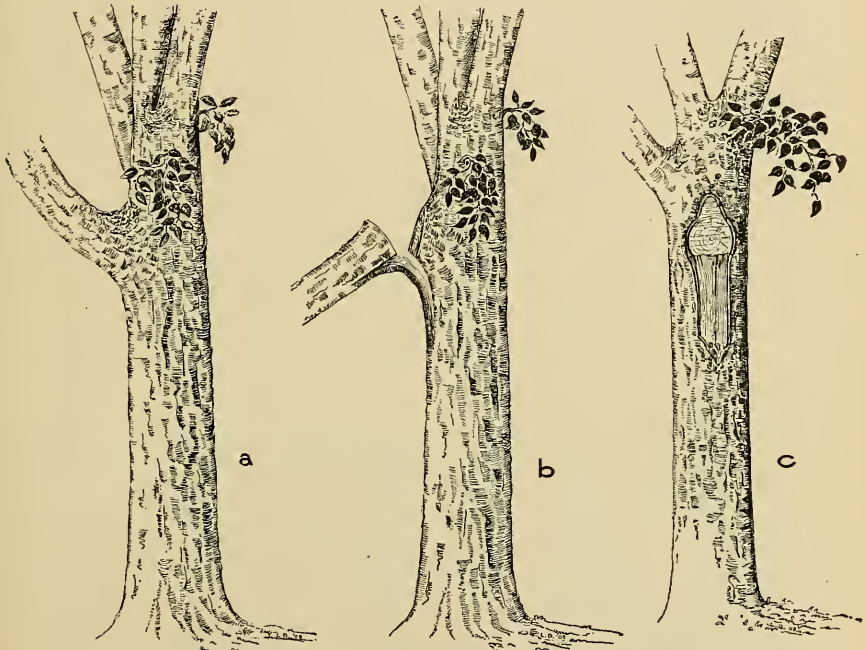


FIG. 24.—Too common method of pruning limbs, resulting in the disfiguration of the tree: (*a*) tree before pruning; (*b*) limb cut too close, resulting in the peeling of the bark; (*c*) unsightly wound caused by this method of pruning.

the more vertical growth of the branches, thus producing a more narrow crown.

The cutting back of old trees is usually disappointing. It is often a question as to whether this is worth while, although if not too far gone, old trees may be restored to a more or less vigorous condition by judicious pruning, tillage and feeding. When elm branches a foot or more in diameter are topped, nothing but a bushy growth results. By removing all but a single sprout, thus diverting the plastic materials, much better growth may be obtained, and replacing of the sacrificed member may be more readily obtained.

There is a difference of opinion as to the best time to prune, some authorities advocating spring and others preferring the fall of the year. Many people prune when the tree is in foliage, — in May or later. There are advantages in pruning in either season. Since trees occasionally bleed when pruned in early summer, painting the wounds is not always successfully accomplished under these conditions; on the other hand, scars on vigorous trees are likely to heal somewhat during the summer if the pruning is done early.

The tools required in pruning are as follows: for general work, a good coarse-tooth, wide-set saw (5 teeth per inch); for larger limbs, a small 3 or 4 foot hand cross-cut saw; and for smaller limbs not easily accessible, a pole saw is convenient. Pole-saw blades may be ordered through hardware dealers, and may be fitted to poles of any desired length. A pole hook, which can be made by any blacksmith, is often useful for removing the small dead branches. For lowering large limbs a set of blocks is necessary, and in the felling of trees a cross-cut saw is indispensable. Ropes of various sizes, iron wedges for felling trees, axes, mallets and chisels, ladders, spurs for climbing, etc., are also indispensable.

The above are the most essential tools for pruning shade trees, although there are others which are extremely useful and time saving.

Healing of Wounds.

A protective feature characteristic of all plants is well illustrated in the healing of wounds. The healing tissues (callus) in a tree are the cambium and adjacent meristematic cells located between the wood and the outer bark. The plastic substances which provide the material for growth and healing are manufactured in the leaf, and are transferred through certain tissues of the inner bark (phloem) adjacent to the cambium to various parts of the tree. When the tree is girdled or the bark removed no growth takes place below the girdling because the channels of transportation are destroyed.

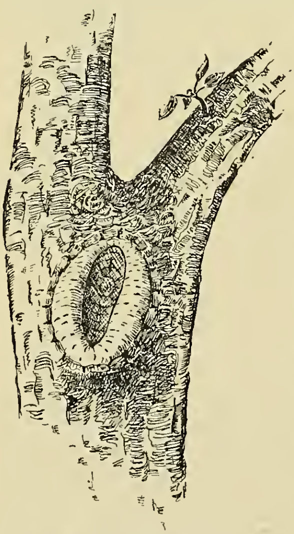


FIG. 25. — Healing of wound. Most active healing follows most direct lines of transference of plastic materials.

In some young plants the pith cells possess the power to form a callus, but such cases are rare and of little importance. The younger the tissue or organ the more quickly it will heal, providing other things are favorable, and vigorous trees will form a callus much more quickly than old or weak ones. Since the plastic substances are manufactured in the leaf, and since it is these substances which are necessary for the development of healing tissue, it is only when

wounds are located along the line of transference of the plastic substance that they develop healing tissue. The sides of a circular wound as a rule heal over most rapidly because they are most directly in the channels of the transference of the plastic substances, and the top and bottom of the wound heal more slowly. When these facts are borne in mind it will be seen that a proper shaping of the wound is important for the development of a more or less even callus formation. (See Fig. 25.) Cuts made near large, leafy branches are more likely to heal quickly than those near small ones, for the reason that a larger amount of the plastic materials is available.

To facilitate healing, recourse is occasionally made to cutting the bark smooth around the stumps of the removed limbs, and it is also claimed that after the callus is well started a recutting of the surface stimulates its growth.

Moisture is said to stimulate the growth of the callus, and the old practice of covering the wound with a mixture of cow manure, clay and lime had this object in view.

Disinfectants for Wounds and Cavities.

There are many erroneous ideas concerning the effectiveness of disinfectants and their use in general. This is particularly true of disinfecting materials used in tree work. Because a certain disinfectant is used

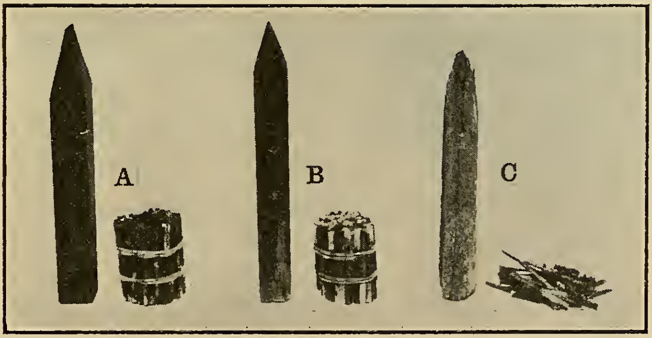


FIG. 26. — Effects of antiseptic treatment of wood in soil two years: (*a*) treated with Carbolineum; (*b*) creosote; (*c*) untreated. Little difference between (*a*) and (*b*); in (*c*) practically all decayed and about 50 per cent. completely.

successfully for one purpose it does not follow that it is applicable to all. As a matter of fact, all disinfectants are limited in their usefulness owing to the great variation existing in organisms as regards amenability to treatment by chemical substances. Disinfectants, therefore, possess specific rather than general properties, which are determined by many different factors. Copper sulfate, for example, is remarkably effective

when applied to reservoirs, ponds, etc., for cleaning out objectionable growths of many kinds, even when used at 1 to 1,000,000 parts or at 1 to 10,000,000 parts; while to be effective against the common blue mold, *Penicillium*, which is often found in the wood of dead trees, it requires a solution of about 1 to 30, or several thousand times stronger.

In the disinfection of wood tissues the following points should be considered. The disinfectant should be capable of penetrating wood tissues. An oily substance, which has more penetrating power, is far better adapted to this purpose than a watery solution. The substance should be only slightly volatile and should keep its original form, or at any rate its antiseptic properties, indefinitely. Copper sulfate, corrosive sublimate, formalin, lime and sulfur, and Bordeaux mixture have been used as disinfectants and preservatives in the treatment of tree cavities, scars and wounds, and while all of the above-named substances have specific disinfecting properties it does not necessarily follow that they are adapted to wood tissues.

FIG. 27. — Inferior mechanical work. Iron band too low for best support, and also causing girdling.

The above-named substances possess limited powers of penetration, and have little or no permanent antiseptic value when applied to tree wounds. Coal tar is also objectionable because of its lack of penetrating power, and because it loses its fungicidal value as it becomes hard. A thick, nonpenetrating material applied to wood is not only of no value, but becomes an injurious agent, as shown by the treatment of shingles on roofs. The old practice of tarring roofs simply induced decay because the tar coating conserved moisture in the shingles, and decay followed more rapidly than in the untreated shingles. Coal tar, however, is useful in covering surfaces previously treated antiseptically. In fact, the use of creosote followed by coal tar constitutes one of the best scientific treatments known, especially for exposed wounds. On the other hand, paint which contains plenty of oil is valuable, as has been proved by long years of experience. It lacks durability however.

Shellac dissolved in alcohol and applied to wounds is serviceable for filling the pores of wood and preventing decay, and hence is of some value as a wound dressing. Gas tar and liquid asphaltum are also sometimes used to cover wounds, and there are specially prepared paints and other substances for use as wound dressings. Even common painter's oil is excellent for the treatment of wounds, as it prevents checking of

the wood tissue. As the transpiration current remains practically normal because checking of the wood is prevented, trees will support a large amount of foliage even when badly girdled. Painter's oil is especially suitable for bark wounds. These should be first properly shaped and their surfaces scraped before applying the oil or other substances. Practically all disinfectants injure delicate tissue such as the cambium layer, but it should be borne in mind that the cambium always dies back to a certain extent when exposed to the air, and more of this dying back results from dessication than from the use of antiseptics. All antiseptics must be used with judgment, especially when the vital tissues are likely to be seriously injured by their use.

Chaining and Bolting Trees.

It often becomes necessary to bolt or chain trees to render them more secure and to prevent injury and disfiguration. As this process is not necessarily always an expensive one it should be much more commonly employed, many valuable trees having been made practically worthless by the loss of large limbs during wind storms, etc. Although the elm is a very tenacious tree with wood that is very difficult to work up into fuel, it is very likely to split. For this reason it is advisable to chain and bolt elms and any other trees which show a tendency to weakness. For an outlay of from $10 to $15 it is often possible to save a tree worth $150 to $200 from destruction.

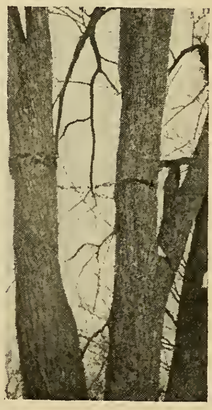


Fig. 28. — Girdling by chain placed around tree.

Different devices are employed for strengthening trees. Some of these are objectionable and do more harm than good. It has been a common practice to place chains around limbs to prevent their splitting, but as the tree develops the chains become imbedded in the bark, resulting in partial girdling, and ultimately disfiguring and injuring the tree.

Another equally objectionable method which invariably results in girdling consists in placing strong bands of iron around limbs and trunks. For making trees more secure some prefer to use an iron rod rather than a chain, and although both have their place, in our estimation the chain system is the better for most purposes. If it is necessary to fasten branches near the point of forking where swaying is limited an iron rod is preferable; but for connecting limbs a few feet apart more or less remote from their junction with one another (where swaying is more pronounced) the chain method is superior. A rod is likely to break when the tree is swayed by the wind owing to its rigidity, whereas a chain, which is flexible, will stand the strain better. Moreover, a chain is easier to place than a solid rod, as less attention has to be given to boring the holes. However, if

one or two links are placed in the rod, as is sometimes done, this difficulty is of course obviated to some extent.

Galvanized stranded guy wire or cables, such as are employed by public-service corporations for anchoring their poles, are superior to either chains or rods for holding in place defective limbs and branches, and are far more pleasing to the eye. These wire cables may be obtained in various sizes and are much cheaper and stronger than chains. Their tensile strength varies according to size and quality from a few thousand to several thousand pounds, but the more flexible cables are best suited to this work. A chain is as strong as its weakest link or member, which sometimes may be very weak, whereas a stranded wire cable is much more homogeneous in its construction and less likely to break. The strain which it is necessary to overcome in swaying trees is often very great, and we have known many chains to break when the links were composed of three-eighths or five-eighths inch iron. Wire cables and chains are usually used with eyebolts, provided with washer and nuts, but the eyebolt often constitutes the weakest feature. It is therefore important that only the best quality of iron be used in the construction of eyebolts. Moreover, work of this nature demands skillful blacksmithing.

FIG. 29. — Showing combination of bolting and banding method which caused girdling to the tree.

FIG. 30. — Illustrating the combination banding and bolting method. It is extremely faulty in all respects.

When stranded cables are used the eyebolt method is sometimes dispensed with. In this case the wire passes through a hole in the tree and around an embedded piece of iron. The wire method is also valuable in temporarily rendering safe weak or dangerous limbs, and in anchoring more or less decrepit trees to strong supports.

Most of the chaining, bolting, etc., observed in trees follows extremely poor mechanical principles. The chains or bolts are often too small, and are seldom placed advantageously as regards leverage, the majority being placed too low or too near the crotch of the tree, thus requiring too much strain to be overcome. Where large limbs are involved, most eyebolts should be 1 inch in diameter and extend through the tree, these being supplied with a 3 or 4 inch washer and nut. The practice of screwing eyebolts or hooks into a tree for a short distance for the purpose of attaching a chain is bad, since they may be pulled out or broken off with the

slightest strain, and only a bolt passing through the tree, provided with a washer and nut, is suitable for such work. If stranded wire is employed it may pass around an imbedded iron bolt at the back side of the limbs.

In any system of strengthening trees, whether by wires or other methods, the best mechanical principles should be employed and a careful estimate made of the amount of load that must be carried; also the proper angle of attachment, etc. The amount of strain to overcome in wiring trees is invariably underestimated, even with an ordinary amount of swaying. During severe tempests hardly any tree is safe, a twisting air movement of great velocity acting as a severe strain. It is always wise to have the chain or wire used far within the limit of safety. Since the limbs or branches of a tree have a tendency to move inwards during cold weather, causing chains and wires to become slack, all wires should be drawn tight at their installation.

Fig. 31. — Iron band around limbs of tree. An objectionable method.

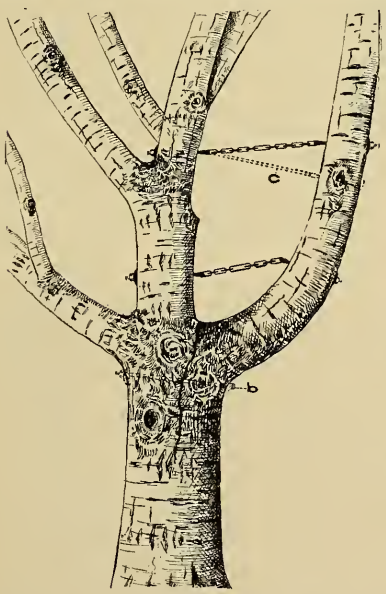


Fig. 32. — Improper method of chaining tree. Dotted lines show more effective method: (*b*) bolt, (*c*) chain. All chains, however, too low.

In many cases of chaining and bolting the washer and nut are placed on the outside of the bark, and often no attempt is made to cut off the ends of the bolts. The unsightliness of this method makes it objectionable. It is better to cover the nut and washer, which may be done by countersinking them into the wood of the tree by means of a gauge or extension bit, and the free ends of the bolts should be cut off close to the nuts. The washer and nut should be well imbedded in

thick paint or coal tar, and either elastic or Portland cement used to cover them, allowing the cement to come flush with the exterior surface of the wood. By this method the ends of the bolt, washer and nut are covered, and the scar produced by this operation will heal over in a short time, leaving no trace.[1]

FIG. 33. — Chain and bolt method of supporting limbs.

The poles of public service corporations are often attached to trees by guy wires, and care should be taken to prevent injury to the tree from girdling, etc. A large wire loop placed round a tree and properly insulated from the trunk by special hard wood blocks is usually harmless, and is more desirable on streets than other often unsightly methods of anchoring poles. These blocks may be made from oak, and should be 2 inches wide, $1\frac{1}{2}$ inches thick and 8 or 10 inches long for heavy wires. They should be provided with a shallow groove to take the wire, the groove being made a trifle narrower than the wire to insure a tight fit. (See Fig. 42.)

Treating Decayed Cavities, Fillings, etc.

Decayed cavities in trees are very undesirable since any fungi and insects which may be present will extend their range of activity, causing decay and shortening the life of the tree. Cavities result from poor pruning of limbs, the breaking off of branches,

FIG. 34. — Tree properly bolted; washer countersunk and imbedded in cement.

[1] The weight of a limb may be roughly obtained by multiplying the average diameter by the length. This calculation should include the numerous small branches, limbs, etc.

According to Prof. C. S. Sargent (Woods of the United States, 1885), the weight of a cubic foot of elm wood is 40.55 pounds when dried at 100° C., and according to W. S. Clark (32d Rept. Mass. State Board of Agriculture for 1874) the amount of water in elm wood varies from 40 to 60 per cent.; thus a cubic foot of green elm wood would equal about 60 pounds. A limb 40 feet long with an average diameter of 8 inches would weigh about 840 pounds, and a section about 34 inches long would equal 1 cubic foot. Of course the leverage which must be overcome is determined by angles of the limb and point of attachment of the chain or wire. (See Fig. 36.)

and other injuries which are not followed by proper treatment at the time.

The treatment of cavities naturally involves some expense, but if a tree is of any value it is worth treating, even though its value may be sentimental in nature. There are many trees which to the casual observer would appear to be of little consequence, but the associations connected with them may be highly cherished. Then, again, the location is often important. A tree may furnish shade which cannot be dispensed with, and even if old and decayed it is often more satisfactory to treat it than to wait for a new tree to grow.

The rationale underlying the cleaning and filling of cavities is similar to that in dentistry. If the work is properly done, and if antiseptic conditions are secured, the length of a tree's life may be extended.

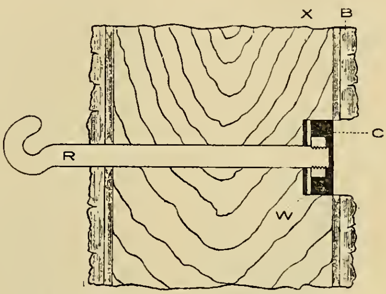


FIG. 35. — Longitudinal section of limb, showing method of bolting. B, bark; X, wood; R, bolt; W, washer; C, cement.

For centuries trees have been treated in various ways. Cavities have been filled with wood, brick, stone, cement and other substances, but as a rule much of this earlier work was very crude in nature, and has accomplished little or nothing toward the prevention of decay. During the past few years, however, more scientific attention has been given to the treatment of decayed cavities in trees, and many good examples may be seen here and there, although it must be confessed that as yet the work is in more or less of an experimental stage.[1]

As has been said, the object of treating decayed cavities is to prevent further decay and to prolong the life of the tree; but there is no particular reason why people should spend one or two thousand dollars on a single tree for repair work when it is possible and certainly more reasonable to transplant a larger and better one for two or three hundred dollars.

The first step in the treatment of cavities is to remove all decayed and infected tissue, which is done by a thorough cleaning out of the cavity.

Second, to treat antiseptically all the exposed tissues which are susceptible to decay, preventing further disintegration. The disinfecting

[1] The writer's first attempt to establish a course covering shade-tree management was in 1895 although the research work concerning shade-tree problems antedated this period. At that time there was little material of a reliable nature at hand touching upon the many shade-tree problems which were continually coming up, and it was practically impossible to organize a course of study relative to the subject which would be of any great practical, scientific or pedagogical value. It was, therefore, apparent from the first that an extensive course of study covering this subject, to be of practical value, would require a scientific basis. However, the numerous investigations carried on during recent years relating to shade-tree problems have placed this subject on an entirely different basis, although there is still great opportunity for further research work along these lines.

substance should be one which can safely be used and still be permanently effective. Creosote is one of the best antiseptics because it possesses superior properties for penetrating wood, and is quite permanent as a disinfectant. In some cavity work this is as far as it is necessary to proceed, especially in the treatment of old, weak, decrepit trees which at most have only a brief period to live, and when there is already considerable strengthening tissue owing to the inward growth of the callus and wood. It is often inadvisable to remove this strengthening tissue and fill the cavity. (See Fig. 43.)

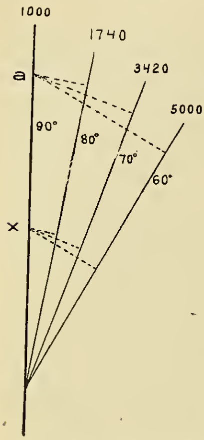


FIG. 36. — Showing relative strain in pounds on wire or chain holding limbs at different angles. The strain at x would be twice as much as at a.

Third, to cover the orifice or opening of the cavity to direct the growth of the callus or healing tissue. However, trees are seldom if ever strengthened by fillings; on the other hand, they are too often weakened by overloading, although ultimately, as new tissue develops over the surface of the filling, strengthening may follow as a result of growth.

Innumerable instances may be observed of positively injurious tree repair work which has been done by incompetent men, some of whom are downright scoundrels; and many trees have come to a sad end from overloading with heavy concrete. Sometimes the tree collapses before the contractor actually finishes the work, in which case litigation usually follows.

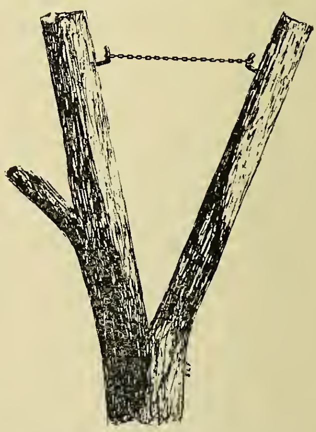


FIG. 37. — Illustrating a faulty method of chaining trees.

The writer has had many opportunities to observe cavity work in trees. Some of these cavities were treated forty years ago, and when thorough cleaning and antiseptic treatment were given the cavities, decay has been arrested to a very remarkable extent. Even some of the work done by ignorant men and amateurs, who are unable to distinguish between normal and infected wood, has been effective in arresting decay, although only the punk and discolored tissue is usually removed from the cavities.

While some progress has been made in cavity treatment during recent years, the greatest drawback to the development of a more scientific and intelligent method of treatment is ignorance and incompetency on the part of those undertaking such

work. The use of worthless disinfectants, the improper shaping of the cavity opening, and many other wrong methods show a total disregard for the first principles of scientific treatment and for common sense. It is unfortunate that so many have undertaken to do tree repair work with-

FIG. 38. — Showing cross-section illustrating the eyebolt and the stranded wire method of attachment. (Compare Fig. 39.)

out adequate training or special aptitude for it. There are innumerable so-called "tree experts," "tree specialists," etc., whose whole experience consists in having filled one or two tree cavities. They possess little or no knowledge of trees or tree problems. Too much stress is also laid on the external appearance and smoothness of their cavity work. They seemingly fail to realize that the scientific treatment of a wound or cavity is fully as important as its appearance when done.

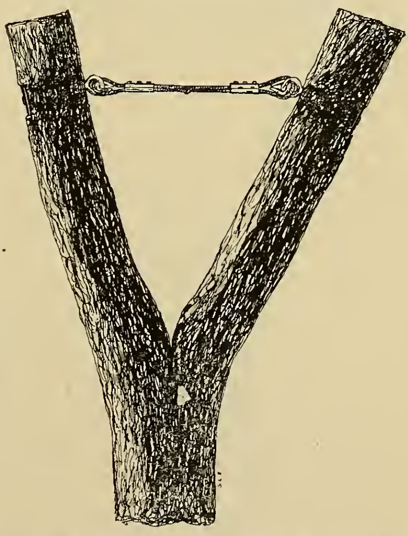


FIG. 39. — Illustrating eyebolt and stranded wire method of attachment.

The principal advance in cavity work has consisted in more thorough cleaning and more effective antiseptic treatment, and some improvement has been made in the technique of cement work. However, these innovations are of minor importance, considering the extent of the work done and the opportunities offered for improvement in the scientific and rational treatment of cavities.

Methods of treating Cavities. — The greatest need in tree cavity work at the present time is more suitable material and improvement in methods of doing the work. There is no reason why a cavity should be filled, — in fact, there are reasons why it should not. The principal problems associated with cavity work are those involving the eliminating of fillings of all descriptions. A durable material with physical properties similar to those of the tree to direct the callus growth must also be found.

There are several methods for the treatment of cavities, some of which were first used years ago. Brick and stone laid in cement have been used

as a filling to cover the cavity opening, and some years ago use was made of irregular pieces of untreated wood for filling cavities. However, cement in different forms has been most frequently employed for cavity fillings, and various metals have been used as a covering for the cavity opening, Use has also been made of wire mesh covered with elastic cement; combinations of asphalt and sawdust; paraffine and sawdust; wood pulp and cement; excelsior and asphalt; sawdust, tar and oakum; certain composite substances like papier-maché; special floor cements; and chemically treated wooden blocks.

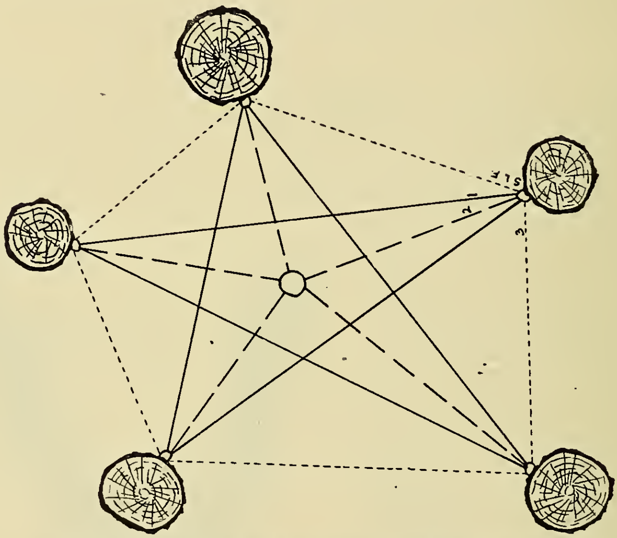


FIG. 40. — Different methods of fastening branches. The solid lines represent the best method; dotted lines inferior methods.

Various disinfectants, such as copper sulfate, corrosive sublimate, Bordeaux mixture, kerosene, formalin, carbolineum, coal tar, creosote, etc., have been employed for cavity work, but some of them are poorly adapted for the purpose. Creosote and carbolineum are similar in nature, and are the best materials for disinfecting cavities. The former apparently possesses greater power of penetration than the latter, although carbolineum seems to form a more permanent external covering than creosote. (See Fig. 26.) Owing to the slow penetration of all disinfectants into moist wood, more than one treatment is needed, and if the cavity is left open for a while before receiving later treatments, so much the better.

Although there have been complaints that creosote injures trees, we have never observed any such injury, notwithstanding the fact that we have treated cavities within 1 inch of the vital area. In all instances

observed, where injury was reported from the use of this substance, the pathological conditions were due to other causes, and were present previous to the time of the repair work.

The expense involved in the different methods of treating cavities varies considerably, and it is not well to increase it unnecessarily. However, if a tree is worth treating the work should be done well, and the more costly methods need not be condemned if they achieve superior results. Before an attempt is made to repair a tree a thorough examination should be made, but this is seldom done. Often a considerable portion of a tree above and below the ground may be dead without the fact being noticeable to the casual observer. A careful examination would reveal the fact that the tree is not worth expensive treatment.

FIG. 41.—Bolt passing through a tree with large square washer. A smaller round one, represented by the white circle, is a more desirable form to use.

Shaping the Cavity.—The shape of the cavity interior is determined largely by the necessary removal of the decayed material. As the decay of the heartwood is usually more extensive than that of the sapwood, the interior dimensions of a cavity are usually greater than those of the orifice or opening. A shoulder is thus formed, and this is of great advantage when cement and other substances are used in filling. In cases where there is no shoulder, spikes may be driven into the wood or iron bolts used, or grooves in the wood may be chiseled out to anchor the filling substance more thoroughly and to prevent its dislocation. But the shaping of the cavity opening or orifice is most important, the main object in filling a cavity or covering its opening being to direct the callus

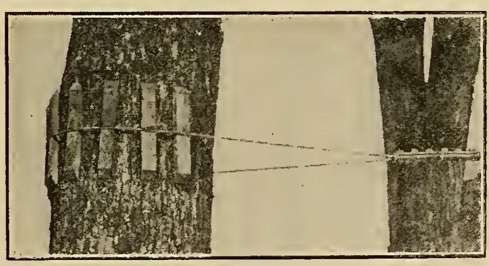


FIG. 42.— Least objectionable method of anchoring guy wires to trees.

or healing tissue. It is therefore essential that the shape of the cavity opening conform to the path of the translocated plastic substances of the tree. These are confined to the phloëm, or inner bark. The sides of the cavity opening should, in a general way, conform; and the less the irregularity of the edges of the opening the better.

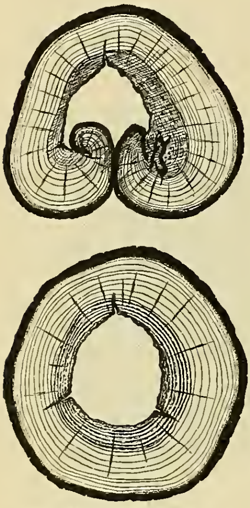


FIG. 43. — Demonstrating the object of treating cavities. Upper figure shows cavity of long standing, with callus curved in, which, if it had been treated, would be as represented below.

If the cavity is above the surface of the ground the apex and base of the opening should never be truncated or flattened, but should be apiculate or pointed. There is no particular objection, however, to having the opening of the cavity perfectly square or rectangular if the bark is removed above and below the opening and brought to a pointed or rounded termination. (See Fig. 49.) This allows the healing tissue to form regularly and uniformly over the outside of the cavity. This also holds true in the treatment of scars and abrasions on trees. After removing the bark the wood should be scraped and treated as with any wound.

Concrete Fillings. — Concrete has been used more largely than any other substance for filling cavities in trees, but its physical properties are so unlike those of wood that it has never been regarded by competent authorities as a suitable material for work of this nature. By some workers its use has only been tolerated until something better could be substituted.

Some of the numerous objections to be raised against filling cavities with cement are as follows: —

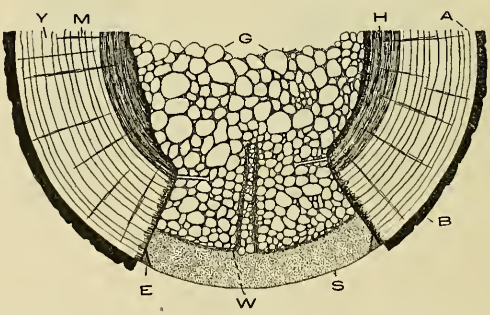


FIG. 44. — Cross-section of filled cavity showing one method of treatment. B, bark; Y, sapwood; M, medullary rays; H, heartwood; A, annual rings, G, grouting; S, cement surface covering; W, wire re-enforcement; E, elastic cement. Inferior to the dry cement methods now used.

(*a*) Cement cannot accommodate itself to the constant swaying movements of trees. As a consequence the fillings are likely to become displaced and crack, although this is not so often the case with fillings low in the tree. This unavoidable cracking of the cement renders it extremely unsuitable for use in cavities.

(*b*) Cement upon drying shrinks from the wood, furnishing an entrance for water, frost and injurious organisms which may cause damage if the conditions are favorable.

(*c*) It is practically impossible to stop bleeding from a cavity that has been filled with cement. This exudating sap or "slimeflux," which is

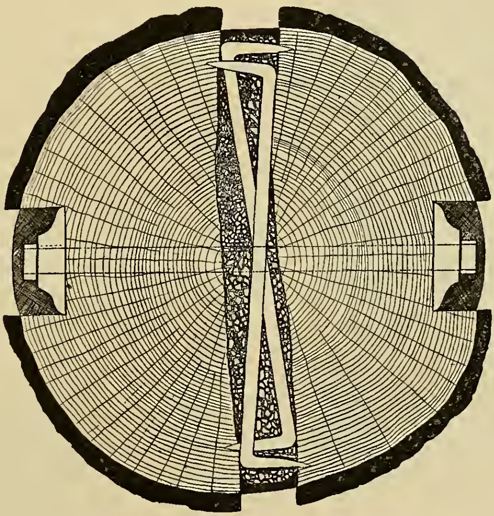


FIG. 45.—Cross-section of split tree with bolt and countersunk nuts and washers and iron braces to obviate movement. Instead of cement, wooden blocks should be employed to cover the opening of the cavity.

not uncommon in trees, discolors the bark and in some cases injures the underlying tissue.

(*d*) There is nothing to be gained from filling a tree cavity with cement or any material. The chief object of filling is to protect the healing tissue or callus of the tree after the cavity has been thoroughly cleaned and disinfected, and this can be accomplished by other methods.

(*e*) Cement does not in any case strengthen the tree; on the contrary, it often proves weakening because of its cumbersome and quite unnecessary weight. It is not adapted to horizontal cavities, which are difficult to seal sufficiently to prevent trouble from water, etc.

(*f*) The several schemes devised to increase the efficiency of cement fillings, such as re-enforcing with iron, wire, etc., covering the cement

surface with metal, the use of elastic material and special grooves, laying the cement in sections, and many others, have not proved of any material value in solving the problem.

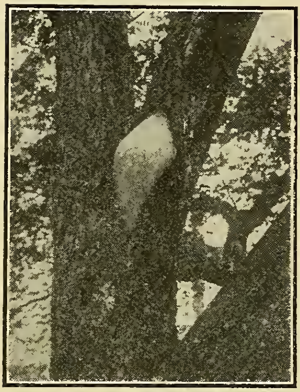


FIG. 46. — Cement-filled cavity favorably shaped for healing over.

(*g*) The tissues back of a cavity are rendered more susceptible to decay by the cement filling. This is especially true if proper antiseptic treatment is not given, or if the cavity is not thoroughly cleaned.

From the various objections given it follows that it is often better to leave the cavity open, or merely to cover the same, than to fill with cement.

Several methods have been employed for the use of cement, and a detailed description of all of them is hardly worth while. It has been extensively employed as a filling, and also as a covering for the cavity opening, in which case the main cavity itself would be left unfilled. In most of the older work in filling cavities with cement the opening of the cavity was boarded up and grouting of a more or less soft consistency, consisting of 1 part cement to 5 or 8 of sand, gravel or other material, was poured in. When this was partially set the boards were removed and the surface of the grouting was coated with about 1 part cement to 2 parts sand, this extending to the outer edges of the wood and conforming to the general contour of the tree. In other cases cement in the proportion of 1 part to 2 or 3 parts of sand has been used in a relatively dry form, applied in small quantities, and thoroughly tamped. This method does not require the use of boards at the cavity opening, as the cement, which is uniform throughout, is gradually built up until the filling process is completed. The outer surface conforms to the general contour of the tree. The use of relatively dry cement has proved more desirable for cavity work than grouting, followed by a surface covering of a different consistency, and has done away with considerable of the cracking and dislodgment of cement which followed surface covering over grouting. In cavity work of all kinds where cement is used, nails, spikes, wires, iron rods and bolts, wire mesh,

FIG. 47. — Cement-filled cavity with bolt.

etc., have been used freely in numerous ways for re-enforcing. When the cavity has no "shoulders" to hold the cement in place, spikes driven into the wood are effective in anchoring the cement, and we have observed such fillings to remain undisturbed for many years.

Any filling substance or covering of a cavity should always come flush with the exterior of the wood. For this purpose it is best to cut the bark back as little as possible to expose the edge of the wood to view. Special grooves cut in the wood of the cavity just anterior to the outer edge of the wood have been used with the idea of directing the flow of surface water which may enter the cavity, or that arising from the interior caused by bleeding, but these grooves have not proved of practical value. A V-shaped groove cut in the edges of the cement before hardening, filled with elastic cement to prevent water from entering, is sometimes used. As there is always more or less separation of the cement from the wood after setting or hardening use has been made of thick elastic substances to cover the surface of the cavity to make the contact more complete.

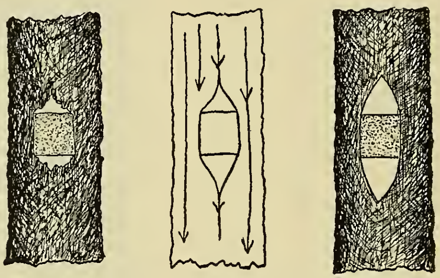
FIG. 48. — Stump growth of white oak with cavity cleaned and treated with creosote and filled with cement. Edge of cavity effectively sealed with elastic cement.

Sectional Concrete Fillings. — The writer first experimented with sectional concrete fillings in 1902 and 1903, and has at different times since suggested this method of filling cavities to those seeking to avoid cracking of the cement where considerable movement exists. In our original experiments the cement was laid in sections, each section being allowed to become set or hardened before another was put on. The sections were further separated from one another by the use of such substances as cardboard or tarred paper, fiberoid, elastic cement or wire mesh. Our idea in developing the use of sectional work was to eliminate cracking of the cement which so commonly follows the use of this substance, and the purpose of using more or less elastic substances between the sections was to form a bed for each section or independent unit to move upon during swaying without causing chipping of the edges of the sectional blocks. The sectional method of filling has been employed quite extensively within the last six years, and at present it constitutes the best method of employing concrete cement in tree cavities.

In some of this work the sections are bolted to the tree, thus restricting independent movement to a certain extent by anchoring the sections. In consequence of this anchoring the sections load the tree with weight,

whereas in basal cavities if not anchored they would not, and with the use of entirely independent sections the movements of cement would be slightly different.

The first to use sectional concrete in tree cavities with bolted sections was probably the late city forester W. F. Gale of Springfield, about 1906. Mr. Gale employed two cross bolts to each section, the sections being about 20 inches long and separated in part by wire mesh. After the cement had sufficiently hardened the bolts were tightened to separate the sections or individual units still further. At the present time tarred paper is usually employed between sections, but where there is much movement this substance is hardly thick enough, especially on the outer edges, to prevent chipping. We had this feature in mind in our original



D E F

FIG. 49. — Showing a square cavity filled with cement. D, disintegrated bark above and below the filling; E, general path of plastic or healing substances; F, bark cut to point to accommodate the process of healing and conforming with the path of healing substances.

sectional work. With the judicious use of iron bolts (which should in our opinion be independent of the sections) in order to secure rigidity, the sectional cement method has proved superior to the older methods of filling cavities, since it has done away with much miscellaneous cracking and dislodgment of fillings.

Much improvement in the quality of the cement work done on trees has been made within the last few years, especially in cement technique, and some of the Portland cement surface in cavities is excellent. A great deal of puttering and detail work such as thorough tamping and troweling of the cement is often done in tree cavity work, especially when the contract is for work by the hour. Thorough tamping and troweling improve the cement, and as a result of this frequent time-killing process practiced by certain unscrupulous workers some of the best individual examples of cement technique may be found in trees. While the sectional method of filling cavities with cement has caused

some advance in cavity cement work, it does not solve the problem of treating cavities. In many cases of sectional work it is an absolute failure. This is true especially when there is too much swaying or when the tree cannot stand the load, or when there is too much crushing force, as in narrow cavities. All concrete work on trees is better adapted to cavities located near the ground or below the surface than to high cavities where swaying constitutes an important factor, and where an increase in the load which a tree is obliged to carry is objectionable.

FIG. 50.— Concrete filling built in sections. (From "Tree Talk.")

Concrete Coverings for the Cavity Opening. — Concrete may be used to advantage as a covering for cavity openings to form a surface for directing the healing tissue. With this method the interior of the cavity is left unfilled, and if the cement is properly reenforced with iron the scheme is practicable and possesses many advantages. The writer has treated some large cavities by this method, and it has proved as satisfactory as solid fillings. Considerable cement is also saved. (See Figs. 51 and 52.)

Metal Coverings. — Metal was much used formerly, and is to some extent to-day, to cover the openings of cavities, and some very creditable work has been done in this line. For this purpose tin or zinc is cut and shaped to meet the requirements of the cavity opening, and after some of the bark has been cut away the metal is securely fastened to the sap wood with tacks. With this method of treating cavities the usual cleaning and disinfecting are done, but the cavity itself is left unfilled.

The principle underlying this method is good, but metal has not proved a durable covering, nor are its physical properties suitable to work of this nature. It is affected too greatly by changes in temperature, which

has a tendency to displace the tacks; consequently the metal covering becomes loose and valueless in a short time. Metal is inclined to deteriorate in a few years, and cannot accommodate itself to much movement in the tree unless it is used in sections and imbricated or overlapped like shingles.

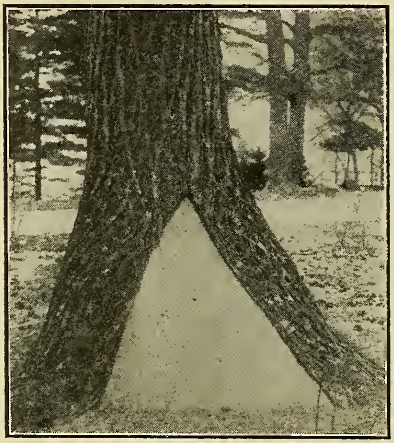


FIG. 51. — Chestnut tree cavity resulting from stump growth, with cavity covering of cement about 6 inches thick. (See Fig. 52.)

Sometimes metal is used to cover cement-filled cavities, but this is of no particular value, and does not improve the appearance of the tree. The principal purpose in using it over cement is to cover the cracks, and when used in connection with iron bands over the surface it is supposed to help hold the cement in place. In some cases where metal is used in this way it is lapped over on the bark 4 or 5 inches, but this destroys the underlying tissues and arrests their future development, thus defeating one of the main objects of treating cavities, — *i.e.*, encouraging and directing the healing tissue or callus formation.

Elastic Cement. — Elastic cement, such as is employed by slaters, has been used for some years in tree repair work, and was recommended for this purpose by the Massachusetts Forestry Association about 1900. Its principal value in tree repair work consists in its elastic properties and its adaptability to places where there is considerable movement. It is too expensive for use in large cavities, costing from 4 to 15 cents per pound, but it has been employed to some extent for filling small spaces and also as a thin covering for cavity openings. In the latter case wire mesh is strung across the cavity opening, the wire mesh being re-enforced with iron and shaped to conform to the outer contour of the tree; and the elastic cement is plastered on the mesh. (See Figs. 54 and 55.)

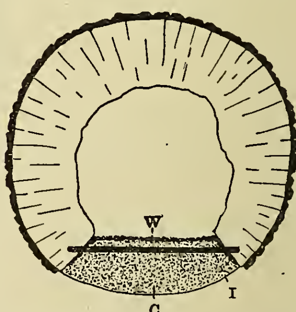


FIG. 52. — Illustrating cross-section of the cement surface covering to cavity shown in Fig. 51. W, wire stapled to sides of cavity; I, iron re-enforcing; C, cement.

This method of treating cavities has been especially recommended by Mr. L. F. Prouty, associated with the city forestry department, Spring-

field, Mass., who has made quite a little use of elastic cement for cavity work. One of the drawbacks in the use of this substance for tree work is that it does not harden sufficiently, the surface easily becoming disfigured. On the other hand, it is valuable for cavities in high swaying trunks and limbs of trees, and especially for cavities with horizontal openings.

Fig. 53. — Cavity in apple tree cleaned out, treated antiseptically, and surface covered with tin.

Wood pulp with a thin facing of Portland cement has also been employed for covering the openings of cavities.

Asphalt Fillings. — During the last twenty years numerous attempts have been made to use asphalt in tree repair work, and more recently it has been employed in combination with other substances. Asphalt and sawdust have been used for cavity work by Mr. John Boddy,[1] city forester of Cleveland, Ohio. For cavities in swaying branches he uses 1 part asphalt to 3 or 4 parts sawdust, and for other cavities 1 part asphalt to 5 or 6 parts sawdust. The sawdust is stirred into the hot asphaltum until the desired consistency is obtained, and the mixture while still hot is put into the cavities with tools smeared with crude oil. Mr. Boddy recommends a grade of asphaltum termed "Byerlyte" as best suited for this purpose. This is derived from refining petroleum with an asphaltum basis, and is the same as that used on street pavements. The mixture of asphaltum and sawdust is better adapted physically to the movements of the trees than the more rigid Portland cement.

Fig. 54. — Elastic cement covering of cavity opening. Wire mesh only supports the thin covering of cement. (After L. F. Prouty.)

[1] Ohio Agr. Exp. Sta. Cir. No. 150, June 11, 1915.

Another method of treating tree cavities with the use of asphalt has been devised and described by Elbert Peets. This consists of using brickets or units composed of asphaltum and excelsior. These brickets are employed as a covering to the outer surface of the cavity, and are cemented together with asphaltum. The brickets are secured to the side of the cavity opening by spikes, and are held in place by iron re-enforcements, the portion of the cavity back of the brickets being filled with sawdust, cinders or other material. An especially commendable feature of this method is the unit system employed, and the adaptability of the material to the movements of trees. On the other hand, asphaltum is not a convenient substance to use because it has to be heated. The same objections to completely filling a cavity apply also to asphaltum, although with the use of this material such a practice may not always be necessary.

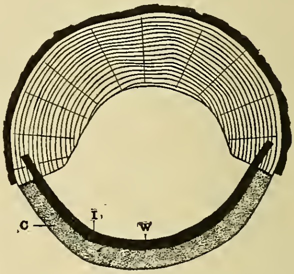


FIG. 55. — Section of tree with cavity illustrating wire and elastic cement method of covering opening. C, elastic cement; W, wire mesh; I, iron re-enforcements.

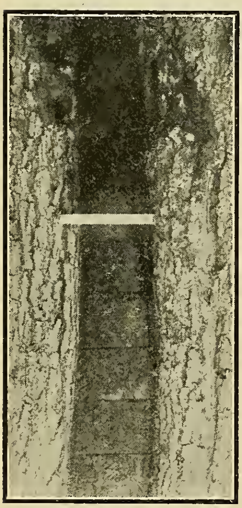


FIG. 56. — Chemically treated wooden block covering of cavity opening, with back re-enforcements of wood. The normal growth of the callus is not disturbed. (After J. A. Davis, City Forester, Springfield.)

Wooden Block Method. — This method of sealing cavities (invented by the writer) has been in use only recently. It consists in the use of chemically treated wooden blocks to cover the opening of the cavities, and makes filling unnecessary. The blocks are of different sizes. Each one constitutes a homogeneous structural unit composed of various cellular elements, similar to those in trees. With this method, as in others, the cavities are cleaned and treated antiseptically, the blocks being used simply to cover the orifice of the cavity and to direct the growth of the callus or healing tissue.

The advantage of wooden blocks for cavity work consists in the fact that the blocks are composed of the same type of element as found in trees. The geometrical arrangement of the various elements, as well as their chemical composition and molecular structure, is similar; moreover, the physical properties — rigidity, elasticity, etc. — are practically identical. The various movements in the cavities of trees resulting from variation in temperature, moisture, barometrical influence, etc., may be better conformed to by the use of this material than by any other yet employed for the cavity treatment.

The blocks should be arranged in the cavity opening so that the radial and tangential surfaces of the structural elements in the blocks coincide in general with those in the tree. It is not necessary to lay the blocks in cement, but in some cases painting the surfaces which will come into contact with one another with an elastic cement is of advantage. The blocks are fastened to the tree by means of special iron braces and held securely by iron re-enforcements. Besides being especially adapted, owing to their physical properties, to use in trees, such blocks are durable, light and easy to fit, and are better adapted to swaying movements and crushing pressure found in narrow cavities than rigid or less plastic substances such as have been used heretofore. The disagreeable and injurious effects arising from bleeding may be taken care of by this method of cavity treatment, and constructive work may be done in winter as well as in summer.

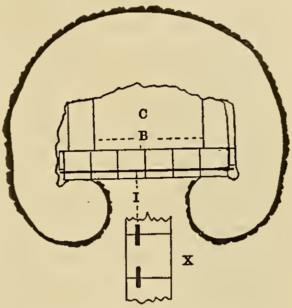


FIG. 57. — Cross-section of illustration shown in Fig. 56. C, cavity; B, chemically treated blocks; I, iron re-enforcement in grooves; X, longitudinal section of blocks.

TREE GUARDS.

There is almost no end to the types of tree guards used to protect trees. Some of these are good and others are of little value. The purpose of a

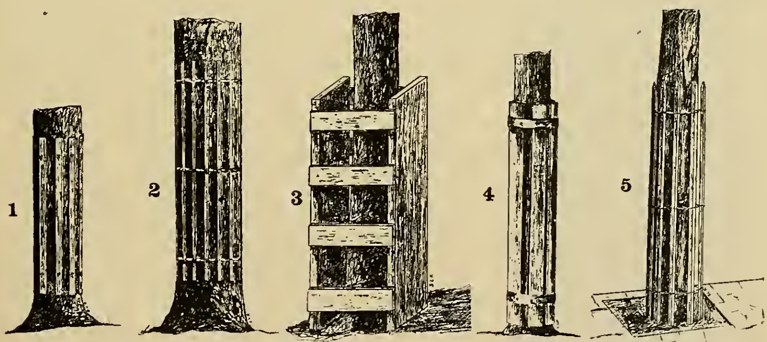


FIG. 58. — Different types of tree guards: 1, wooden strips nailed to a tree; 2, wooden strips nailed to a tree and banded with iron; 3, old type of wooden tree guard; 4, wooden strips banded with iron tightly to the trunk of the tree; 5, similar to 4; all objectionable types.

tree guard is protection, and the guard should cover the tree to a height of about $6\frac{1}{2}$ feet; it should be as light and as inconspicuous as is consistent with strength and protection; and should allow the tree ample

opportunity for growth without causing injury. The ideal tree guard is durable, easily placed and not easily displaced, inexpensive and neat in appearance. Some tree guards are attached to trees by means of staples or nails, but this method of attachment is objectionable. The old-fashioned tree guard made of wood usually became useless in a few years. However, while it may not have possessed much beauty or permanent utility, it at least showed a commendable spirit and desire for tree protection.

A very cheap and efficient tree guard is used to quite an extent in some places, and is known as the "Clinton Tree Guard." This guard is made of No. 15 galvanized wire, having a mesh three-fourths inch in diameter, all the wire contacts being soldered. This wire may be bought in strips of various widths from 12 to 48 inches, and cut off any length desired, 6 and 6½ feet being the more usual lengths. Strips 12 to 18 inches wide are well suited for small trees. These are rolled up in cylindrical form of the desired diameter, and tied together by a few pieces of copper wire. To prevent the top of the tree guard from chafing the tree the top is protected by wiring through the rough edges of the guard a split piece of discarded rubber hose. Use is also made of insulated wires or springs placed diagonally through the top of the guard to hold it away from the tree. The great advantage of this guard is its cheapness, but it is made of heavy wire firmly woven, and answers the requirements very well. This wire is made by the Clinton Wire Company, Clinton, Mass., and costs about 4½ cents per square foot. (See Fig. 60.)

FIG. 59.—Effectual tree guard used on Boston Common. The wire guard is re-enforced by pointed angle irons driven into the ground.

A re-enforced wire cloth guard manufactured by the Wright Wire Company, Worcester, Mass., has recently come into use. It is made from close mesh wire similar to that of the Clinton guard, but is re-enforced with flat metal strips. This re-enforcement is considered a valuable innovation because even heavy wire mesh is likely to crumple up with hard usage, and becomes ineffective as a tree guard. The re-enforced metal edges are provided with holes for the purpose of stapling the guard to large trees. (See Fig. 61.)

One of the neatest and most durable tree guards is shown in Fig. 59. It consists of an open-mesh, heavy-wired guard supported by a piece of angle iron on either side driven into the ground. The angle iron acts as a re-enforce-

ment and holds the guard in place. The use of any guard around trees is more or less of a nuisance, but at the present time they have to be applied to street trees. Planting inside of the sidewalk or on wide tree belts will obviate much of the use of tree guards in the future.

Fertilizing Trees.

Trees, like agricultural crops, respond to tillage and treatment with fertilizers and manures, but there are only meager data relative to the specific effects of the various chemical constituents in fertilizers on shade trees. From what is known regarding their effects on other crops, and from their limited use on trees and shrubs, it is evident that they may be applied with a reasonable degree of success.

Wood ashes have been used to some extent for treating shade trees, also bone meal, nitrate of soda and potash in the form of muriate or sulfate. Any good complete fertilizers, such as those adapted to lawns, should prove valuable for trees. Wood ashes, which are not so easily obtained as formerly, are of benefit to lawns, and there is no reason why they should not prove suitable for trees. A certain amount of nitrate of soda, at the rate of 150 to 200 pounds per acre, may be used to good advantage, but care should always be used not to apply it too freely. The nitrate of soda stimulates wood production, and, like lime, helps to give a deeper color to the foliage; but an excess produces symptoms of malnutrition in many crops which usually takes the form of an abnormal development of foliage. Bone meal is slow to become available, but it does not injure plants when applied freely, and makes a good fertilizer. Pulverized sheep and cow manure are valuable lawn fertilizers, and even though the price is rather high for the plant food contained, they supply organic matter and therefore have an especially beneficial effect on the soil. They can be applied freely without danger of harm.

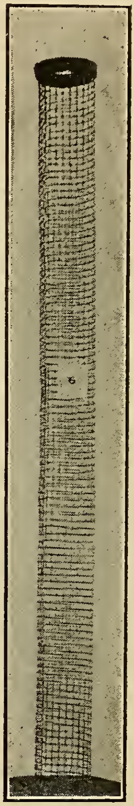


Fig. 60. — Clinton tree guard, with hose protection at top.

While trees will respond favorably to judicious treatment with fertilizers, it must be borne in mind that no fertilizer can take the place of cultivation. Fertilizers should be applied where the feeding roots are located, and these are confined largely to an area corresponding with the spread of the foliage and not close to the trunk of the tree, as imagined by many persons. This also holds true for tillage, *i.e.*, the whole area surrounding the tree should be cultivated to some distance beyond the spread of the foliage. As the tree develops in size the smaller feeding roots become less abundant near the base of the tree, although cultivation and feeding have a marked tendency to induce root development wherever they are

practiced. All fertilizers should be applied evenly. Spreading by hand is at best a poor method, as shown by the dark green plots of grass on lawns where nitrate of soda has been applied in this way; but when fertilizer spreaders cannot be had the hand method must be used. Another factor to be considered when applying fertilizers to lawn trees is that the grass roots will obtain their full share. Turning under the sod and cultivation of the soil around the tree is of the greatest importance from the very considerable amounts of organic matter added to the soil. Fertilizers applied under these conditions, or, far better, stable manure well incorporated into the soil at the rate of 20 to 30 cords per acre, are of the greatest benefit to the tree, even if it becomes necessary to reseed immediately. In cases where it is inconvenient or undesirable to disturb the soil around a tree, and when the application of fertilizer to the surface does not accomplish the desired results, holes 1 or 2 feet apart and 15 inches deep may be made with an iron bar and then filled at different times with a liquid fertilizer.

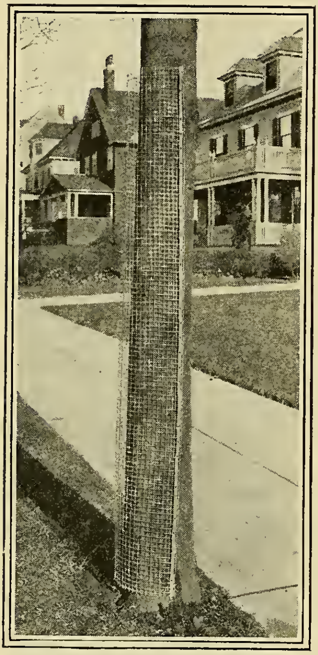


FIG. 61. — Re-enforced wire cloth tree guard, showing edge stiffening with nail holes for attaching to tree. (From the Wright Wire Company.)

There are a number of fertilizer mixtures prepared for shade trees that are undoubtedly of value, but some of them are apparently not based on any expert knowledge of the tree's special requirements.

Diseases of Trees.

Trees, like other living organisms, are very liable to attacks from disease, and a tree of any maturity is seldom found perfect in all respects. A disease may be defined as a disorder caused by any failure in or diversion of the normal physiological activities of the organism.

The diseases of plants with which plant pathologists have to deal may be divided into three classes: First, those caused by parasitic fungi; examples, — rust, smut, etc. Second, those brought about by functional irregularities which induce saprophytes (dead wood fungi) or parasites to thrive, such as "damping off," mildew, etc. Third, those of a purely functional nature, pathogenic organisms not necessarily being present; examples, — dropsy or œdema of tomatoes, malnutrition and others. All these types of diseases are found in trees, but the first and second are most common.

Diagnosis of Disease.

A successful diagnosis of disease necessitates a thorough knowledge of the normal and abnormal functions of the organism, together with an understanding of the specific reactions of the plant to various external and internal agencies or stimuli that may affect it. The specific reactions of plants are so little understood as compared with those of animals which have been studied for centuries that it often requires considerable study to make a complete and accurate diagnosis of some of the troubles affecting plants, especially without knowledge of the conditions to which they have been subject. Plants have their peculiarities, like animals, and the large number of different species which are normally adapted to a great variety of conditions and which are likely to be subject to disease renders the problem of diagnosis often quite difficult. The reactions of plants to stimuli are manifold, and much more depends upon the nature of the organisms stimulated, as regards the nature of the response, than upon the particular stimuli giving rise to the reaction. The same agency may produce a variety of reactions even in the same organism, and different agencies will often produce like effects.

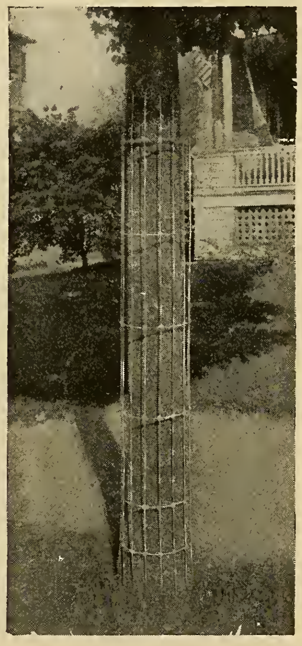


FIG. 62. — Open mesh tree guard with protective springs at top. (From the Wright Wire Company.)

It might be difficult to tell whether a particular plant was affected by coal gas, hydrocyanic acid gas, burned sulfur, formalin vapor, or other gases without other evidence than that afforded by the plant, unless the observer possessed a special knowledge of the effect of these gases. But there are distinct symptoms displayed by plants which enable one, after much experience and careful investigation, to determine with some degree of accuracy the exact cause of injury resulting from injurious agencies.

In diagnosing diseases it is first necessary to distinguish between primary and secondary causes. A tree may be subject to borers and fungi, but these may not be the primary cause of the trouble; indeed, they are more often merely secondary effects. A tree may sometimes winterkill and become subject to fungi, but one would not be justified in diagnosing the case as injury from fungi, although in the diagnosis of disease secondary causes are often mistaken for primary ones. It should be borne in mind, however, that no plant ever dies without some definite cause. In deter-

mining the health condition of a tree it is important that all the factors in any way concerning it should be well understood; in other words, one should be able to judge of the degree of vigor possessed by the tree. A tree in a vigorous condition has a quite different appearance from one that is less thrifty. In the former case the bark has a certain color and other characteristics by which it is easily distinguished from those in a less healthy tree. This is also true of the branches, twigs and leaves as well as of the general habit of growth.

Finally, in all tree work it is essential that as thorough knowledge as possible should be secured of the structure and function of the tree, its normal and abnormal characteristics, and the causes responsible for health and disease. As a rule, tree workers have little idea of tree structure and function; consequently their diagnoses are seldom correct.

Fungous Diseases of Trees.

There are troubles of a serious nature affecting trees which are not associated with organisms; but by far the most numerous and troublesome diseases are caused by fungi, and occasionally by other types of organisms. The fungi responsible for decayed cavities do the most damage to trees.

There are a great number of leaf spots — *Septoria, Cercospora, Phyllosticta* and other genera — which affect both our native and introduced trees and shrubs, and mildews are found on almost every tree and shrub. Much careful investigation has been given to the control of plant diseases in general, and valuable results have been obtained from spraying and other methods of treatment. (See Treatment.) The fungous diseases of our agricultural crops have been thoroughly studied, and most of them are of enough importance to warrant systematic treatment every year; but a large number of the leaf spots affecting shade trees are not common enough to do any particular harm, and at least during the past many of them have not been considered worth serious study from the viewpoint of treatment.

Most of the fungi affecting leaves and branches are parasitic; a few are saprophytic, *i.e.*, attacking only dead tissue; while still other forms flourish either as parasites or saprophytes. The root-like mycelia of parasites in most cases penetrate the cells and rob them of nutriment. Often fungi cause distortion of the tissues so that galls and other abnormal growths are formed. They also have acquired the peculiar habit of secreting ferments that dissolve the cell walls. All fungi are capable of producing some injury, but economically considered, treatment is necessary only when the injury greatly retards the growth of the tree or seriously impairs its appearance.

Among some of the commoner forms of fungi that affect shade trees may be mentioned the following: —

Maple (*Acer*). — Leaf spot (*Phyllosticta acericola* C. & E.) forms irregular brownish spots on the leaves of the rock and white maples.

Anthracnose (*Glœosporium apocryptum* E. & E.) is known to cause serious injury to the leaves and shoots of the box elder and maple.

Fig. 63.—Oyster mushroom (*Pleurotus sapidus*) on maple, following injury.

Leaf spot (*Rhytisma acerinum* Fr.) is characterized by conspicuous black spots on the leaves of the red and white maples, but is practically harmless.

Nectria cinnabarina (Tode) Fr., a common fungus characterized by small cinnamon-colored pustules occurring on dead wood, follows winterkilling, sun scald, etc. It is especially noticeable on winterkilled twigs of Norway maples.

Oyster mushroom (*Pleurotus sapidus* Fr.) is a large, edible fungus growing in masses on maples that have been injured by borers and other agencies. A mildew (*Uncinula circinata* E. & E.) sometimes infects the leaves of various maples.

Sun scald and frost cracks are not uncommon on maples. The rock maple is one of the most susceptible trees to sun scorch and "bronzing" of foliage induced by excessive transpiration during dry periods. The red maple is susceptible to winter injury of roots, and like the rock maple suffers from drought.

Horse-chestnut (*Æsculus*). — Leaf spot (*Phyllosticta sphæropsoidea* E. & E.) appears in the early summer, and later causes a conspicuous yellow spotting of the foliage. This disease is more or less common every year. The leaves of the horse-chestnut are occasionally affected with mildew (*Uncinula flexuosa* Pk.), and the winterkilled twigs are sometimes attacked by *Nectria cinnabarina*.

Chestnut (*Castanea*). — This is seldom planted as a shade tree, although it is sometimes seen on country roadsides and on lawns. The chestnut blight, which is so serious and so universally distributed at the present time, renders the use of the species as an ornamental tree out of the question. The chestnut is also affected with certain leaf spots, etc.

Sycamore (*Platanus*). — The tree most likely to be severely defoliated by a fungus is the sycamore. The causal organism is *Glœosporium nervisequum* (Fckl.) Sacc., which affects the petioles and veins of the leaves, causing small black areas on these organs. More or less large portions of the leaves turn brown and the leaf finally falls.

The sycamore is unusually susceptible to winterkilling of the twigs, but in spite of this constant defoliation and twig killing it is a very hardy tree.

Fig. 64. — Horse-chestnut leaf spot (*Phyllosticta*).

Poplar (*Populus*). — The principal species in cultivation as shade trees are the Carolina poplar, white poplar, Italian poplar and the Lombardy poplar. The Italian poplar is often severely affected with rust (*Melampsora populina* (Jacq.) Lev.), and a mildew (*Uncinula salicis* DC. Wint.) is frequently observed on the leaves of poplars. Anthracnose (*Marssonia populi*

FIG. 65A.—Italian poplars affected with rust (*Melampsora populina* (Jacq.) Lev.). Unsprayed. (After Maynard.)

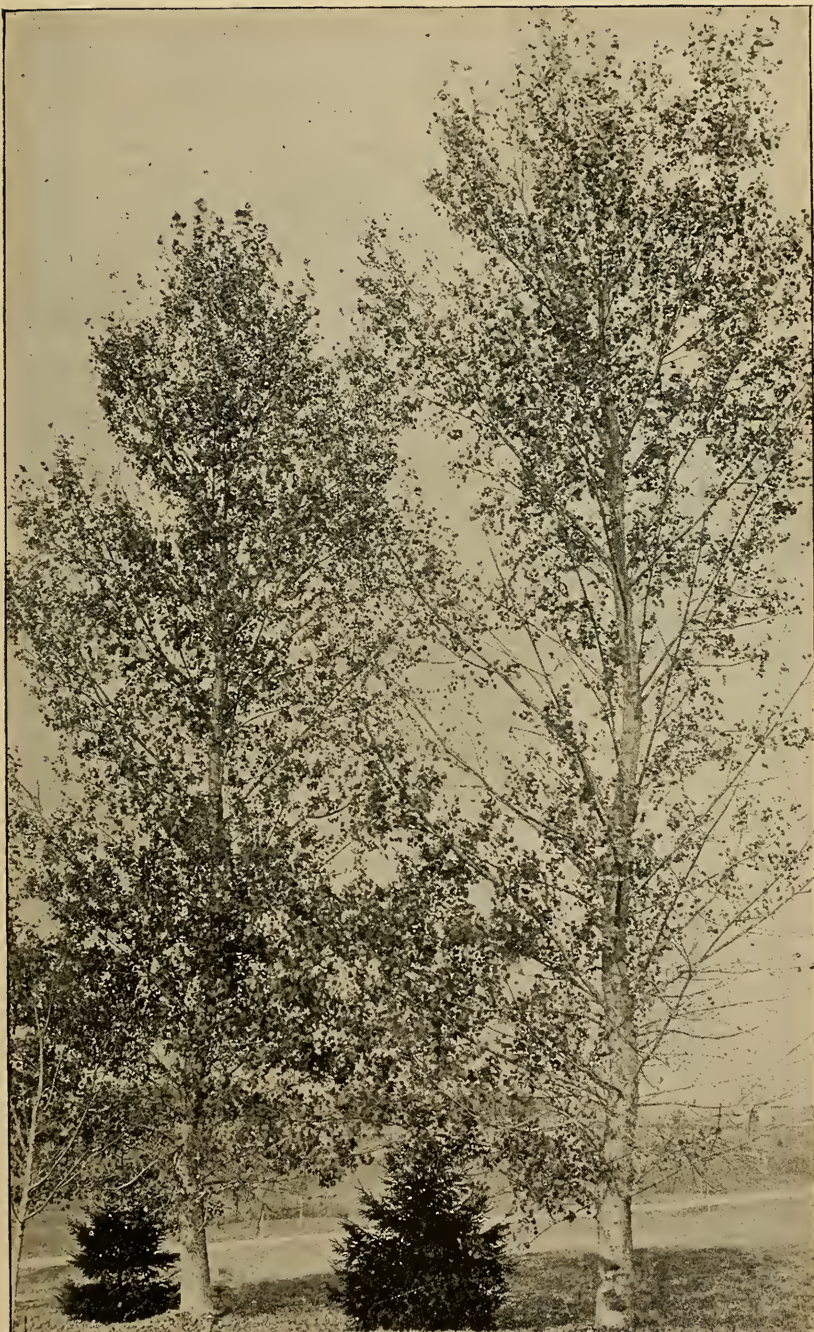


FIG. 65B. — Italian poplars affected with rust (*Melampsora populina* (Jacq.) Lev.). Sprayed with Bordeaux mixture. (After Maynard.)

(Lib.) Sacc.), which attacks the twigs, has been known to cause great injury to many poplars. Poplars are often affected by crown gall and various other diseases.

Oak (*Quercus*). — The oaks are affected by a number of diseases such as *Septoria dryina* Cke., which produces a leaf spot, and by several mildews, *e.g.*, *Phyllactinia suffulta* Reb., *Asterina intricata* E. & M. and *Asterina patelloides* E. & M., *Microsphæra quercina* (S.) Burr. The fungus *Glœosporium nervisequum* (Fckl.) Sacc., which also affects the sycamore, is sometimes found on oaks, affecting the leaf petioles and veins, causing a browning, and, in severe cases, a loss of the foliage. It is most common on the leaves of the shaded branches. *Nectria cinnabarina* (Tode) Fr. also affects the oak. Oak "spangles," little saucer-shaped bodies on the leaves which resemble the work of fungi, is caused by insects.

Hickory (*Carya*). — Two or more leaf spots are found on the hickory, *e.g.*, *Microstroma juglandis* Sacc. and *Phyllosticta caryæ* Pk. Some seasons hickory leaves are quite badly spotted.

Fig. 66. — *Armillaria mellea* on roots of maple.

Butternut (*Juglans*). — Butternuts are affected by the following leaf spots: *Ascochyta juglandis* Bolish, which is more or less common; *Cercospora juglandis* K. & Sw., *Glœosporium juglandis* (Lib.) Mont., *Marssonia juglandis* (Lib.) Sacc. The butternut has suffered greatly from climatic conditions in the past decade.

Tulip Tree (*Liriodendron*). — The leaves of the tulip tree are sometimes badly spotted by insect work which is often accompanied by fungi.

Sweet Gum (*Liquidambar*). — The sweet gum is affected by a leaf spot (*Septoria liquidambaris* Cke. & E.) and is susceptible to winter injury in the north.

Magnolia. — The magnolia is affected by an anthracnose (*Colletotrichum spinaciæ* E. & H.) which ruins the smaller branches and foliage of the tree. Mildew (*Asterina picea* B. & C. and *Asterina comata* B. & Rav.) is also found on the leaves.

Pine (*Pinus*). — The white pine during the past ten years has been affected by a root killing, which has been responsible for the burning of the leaf tips (sun scorch). Various fungi, such as *Septoria parasitica* Hartig, and *Hendersonia foliicola* Berk., have been associated with this trouble, but both are apparently saprophytes. The terminal twigs of the white pine are occasionally affected with *Phoma Harknessii* Sacc., which causes the death of both the leaves and twigs. *Scorias spongiosa* Schw. forms black incrustations on the leaves and twigs of the white pine in the secretions of the woolly aphis. Rust (*Coleosporium pini*) sometimes occurs on the leaves of the pitch pine.

Catalpa. — The catalpa is affected with the leaf spots *Phyllosticta catalpæ* E. & M., *Cercospora catalpæ* Wint., *Macrosporium catalpæ* E. & E., also with mildew (*Microsphæra elevata* Burr. and *Phyllactinia suffulta* Reb.). A blight disease is recorded which causes the leaves to turn black, shrivel and fall. This is said to be caused by insect larvæ. Two wood-destroying fungi, *e.g.*, *Polyporus versicolor* (L.) Fr. and *Polyporus* (Poria) *catalpæ* are found on the catalpa.

Hackberry (*Celtis*). — The hackberry is occasionally planted as a shade tree, and is affected by two mildews (*Uncinula polychæta* B. & C. and *Sphærotheca phytoptophyla* K. & S.) which are associated with a mite (*Phytoptus*) in producing distortion of the leaves. *Phleospora celtidis* E. & M., *Phyllosticta celtidis* E. & K., *Ramularia celtidis* E. & E. and *Septoria gigaspora* E. & E. are responsible for leaf spots.

Beech (*Fagus*). — A mildew (*Microsphæra erincophila* Cke.) is associated with a mite (*Phytoptus*) on the leaves of the beech. The fungus (*Scorias spongiosa*

Schw.) grows in the secretions of woolly aphis, causing a large spongy black mass on the leaves.

HAWTHORNE (*Cratægus*). — The leaves of the English hawthorne are affected often seriously with *Entomosporium thumenii* Cke., which produces spots.

ASH (*Fraxinus*). — The stems and leaves of the ash for the past few years have been troubled with a rust (*Æcidium fraxini* Schw.). The worst cases have been

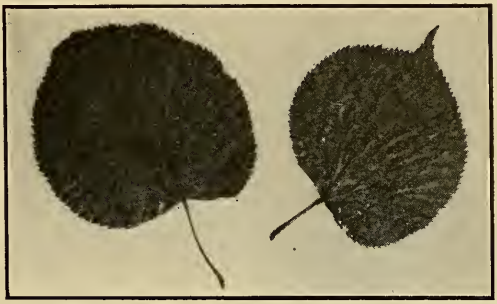


FIG. 67. — Linden leaf spot (*Cercospora*).

found in the vicinity of Cape Cod. The ash is also subject to a leaf spot (*Septoria leucostroma* E. & E.) and mildews (*Phyllactinia suffulta* (Reb.) Sacc. and *Phyllosticta viridis* E. & K.).

LOCUST (*Robinia*). — The locust is unusually susceptible to borers, and when attacked by them often becomes infected with various species of fungi.

LINDEN (*Tilia*). — The leaves of the linden are sometimes badly affected with leaf spots, such as *Cercospora microsora* Sacc., which may be largely controlled by

FIG. 68. — Linden tree in center sprayed twice with Bordeaux mixture; others unsprayed.

spraying. The linden in some locations suffers very badly from frost cracks. The American basswood (*Tilia americana*) is subject to a leaf mildew (*Uncinula clintonii* Lev.) and to the leaf spot (*Cercospora tiliæ* Pk.).

ELM (*Ulmus*). — The most common leaf spot found on the elm is *Dothidella ulmi* (Duv.), which is characterized by numerous small black spots on the upper surface of the leaves. Another leaf spot caused by *Phleospora ulmi* Wallr. is characterized by numerous small spots from which gelatinous masses exude in damp weather.

This fungus causes defoliation, and sometimes a great deal of injury results. The mildew (*Uncinula macrospora* Pk.) is found on elms, and *Taphrina ulmi* Johan. is found on *Ulmus montana* and *Ulmus campestris*.

The American elm is very susceptible to drought and winterkilling of roots. Frost cracks are also rather common on the elm, and from these and injury from borers the elm bleeds rather freely.

Sun scald, sun scorch, "bronzing" and various types of winter injury, — such as root killing, death of buds, twigs and branches, frost blisters and frost cracks, — drought effects, "staghead" from various causes, and many other troubles not caused by organisms, are quite commonly found on trees.

There is also a sooty mold that grows in the "honeydew" secreted some years quite abundantly by aphids on various species, which sometimes causes considerable retardation of growth. The honeydew is usually washed off the leaves by rains before it does very much harm, but occasionally, in periods of drought, the concentrated sticky covering remains on the leaves long enough to plasmolyse the cells, causing a mottled appearance of the leaves.

Wood-destroying Fungi.

There are a great number of fungi that may be found on dead wood following various injuries caused by sun scald, insect work, fires, illuminating gas, oil sprays and other agencies. Some of these parasites attack the dead bark and penetrate living tissues of the host, destroying the cell structure, and others are found in the heartwood. By far the largest number of wood-destroying fungi, however, are saprophytic in nature, and find congenial conditions only on dead tissue or that which has become weakened from some cause. These fungi produce different chemical and mechanical effects on the tissues, depending upon the nature of the host and of the attacking organism.

A great many of the fungi that attack wounds are capable of producing cavities, although the heartwood fungi are the chief offenders in this direction. These wood fungi are the most insidious enemies of trees, and quite often no trace of their work is discovered until a great deal of injury has been done. They penetrate the tissues slowly and persistently, and the decay is usually so well hidden from sight that the damage does not appear until the injured tissues are removed with mallet and chisel.

While the wood-destroying fungi are responsible for much injury to trees, fortunately it can be prevented by the antiseptic treatment of wounds; and if the decay has progressed until cavities are formed, these should be thoroughly cleaned and disinfected. The great amount of tree work done during the past few years has demonstrated that the careful removal of infectious material from cavities, followed by thorough antiseptic treatment of the cavities, has been very successful in arresting decay and preventing further injury.

Some of the more common wood fungi are given in the following list. This list is by no means complete as there are innumerable deadwood species belonging to many different genera which it is unnecessary to give. Even some of those listed, *e.g.*, the common birch *Polyporus*, are seldom if ever found except on dead trees.

Most of the wood-destroying fungi develop conspicuous fruiting organs that make them easy to identify. Molds and bacteria are also responsible for hastening decay in trees, often preparing the way for other organisms.

Armillaria mellea Vahl. — A parasite mushroom affecting the roots of maples, oaks and other trees.

Dædalea quercina (L.) Pers. — Occurs in wounds and on dead tissues of the oak and chestnut.

Fomes igniarius (L.) Gillet. — False timber fungus. This is responsible for a heartwood rot common to a large variety of trees, such as maple, oak, hickory, poplar, beech and others.

Fig. 69. — *Hydnum septentrionale.* (After E. A. White.)

Fomes rimosus Berk. — Common on the black locust, where it forms large, conspicuous fruiting bodies.

Fomes fomentarius (L.) Fr. — Occurs on the beech and yellow birch, probably as a saprophyte.

Fomes applanatus (Pers.) Wallr. — A deadwood fungus often following injury from fire, etc.

Fomes pinicola Fr. — Causes a decay of conifers.

Hydnum septentrionale Fr. — A large, creamy white growth occurring on wounds of rock maple.

Pleurotus sapidus Fr. — Oyster mushroom (edible). Occurs on maples, elms, etc., injured by borers and on neglected wounds.

Polyporus sulphureus (Bull.) Fr. — Red heart rot. Occurs on various trees, such as oak, maple, locust and conifers. Fruiting bodies consist of a series of sulfur-colored shelves overlapping one another and forming a large, round mass.

Polyporus betulinus (Bull.) Fr. — Common on dead birches.

Polyporus gilvus Schw. — On deadwood.

Polyporus nigricans. — A wound and heartwood fungus.

Polyporus borealis (Wahl.) Fr. — A wound parasite on species of hemlock.

Polystictus versicolor Fr. — One of the most common fungi, found on a great variety of trees and cut timber. Very destructive as a saprophyte, and as a wound parasite causes injury to catalpa.

Polystictus pergamenus Fr. — Common on trunks of trees following fires.

Schizophyllum commune Fr. — Common on trees injured from various causes.

Stereum frustulosum Fr. — Causes decay to trunks and occasionally found in wounds, etc.

Slime-Flux.

This trouble is common to trees like the elm, maple, yellow birch and apple. It is associated with frost cracks, injury from lightning, splitting of the trunk, defective pruning, etc., and is not uncommonly found in cement-filled cavities. Slime-flux is characterized by the exudation of a slimy, discolored sap from wounds. This exudation of sap is contaminated with various forms of algæ, bacteria and fungi, and occasionally with low forms of animal life, all of which give the sap a sour odor. This fermenting mass is apparently poisonous to vegetation, since it will kill the grass upon which it falls, and also causes injury to the bark and underlying tissues of trees. The whitish appearance given to the bark by the slimy sap often persists for some time after the flow has stopped.

Bleeding wounds often prove injurious to trees, and are very difficult to treat. The bleeding can usually be stopped when it follows defective pruning, as it often does in the elm. Sometimes wooden plugs nicely fitted and driven into the wound firmly will prevent bleeding, and in some cases the tissue may be cauterized by heat. Cement should not be used in cavities that show a tendency to bleed.

Treatment of Fungous Diseases of Trees.

The methods of treating fungous diseases are numerous, but undoubtedly in the future different, as well as simpler, cheaper and more efficient, methods will be used. The use of antiseptics in the treatment of wounds and cavities caused by the worst enemy of trees, — *i.e.*, the wood-destroying fungi — is absolutely essential in controlling this type of diseases.

Little attention has been given to the treatment of the many leaf spot diseases of trees and shrubs, but from what has been already accomplished along these lines we are justified in assuming that these spots can be controlled largely by spraying; for example, trees like the linden, which often becomes badly infected with a leaf spot, are much benefited by spraying. A linden tree,[1] sprayed twice during July and August with Bordeaux mixture, retained its leaves ten days later than trees unsprayed, and the amount of leaf spot was materially less on the sprayed tree. (See Fig. 68.) The leaf spot *Entomosporium* affecting the English hawthorne may be controlled, according to our observation, by spraying with Bordeaux mixture; and there are many other shade-tree leaf spots that yield to this treatment. In many cases, however, it is a question whether the trees are worth the expense and trouble of treatment.

All the rusts are difficult to control, and it is doubtful whether some of them at least are worth treatment. The rust affecting the Italian poplars (*Melampsora*), which at times has been more or less serious, was held in control quite effectively by Prof. S. T. Maynard,[2] who sprayed for

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[1] Mass. (Hatch) Agr. Exp. Sta. Rept. 15, 1905.

[2] Mass. (Hatch) Agr. Exp. Sta. Bul. 25, 1894.

this trouble with Bordeaux mixture many years ago. This rust affects the lower foliage, usually when the dew is most abundant. Infection is sometimes so severe that it destroys the twigs and branches. However, the use of Bordeaux mixture as a spray for ornamental trees is objectionable on account of the discoloration of the foliage, and some prefer the fungus to the unsightly foliage. If possible, some less objectionable spraying material should be employed for ornamental trees and shrubs. Although Bordeaux mixture has proved after many years' trial to be the best all-round summer spray for leaf spots, of late the diluted lime and sulfur solution is being substituted for it with more or less good results. Lime and sulfur applied to dormant trees for the San José scale has proved invaluable as a means of controlling leaf spots, and in some cases it can undoubtedly be used to advantage for certain fungi, such, for example, as the *Glœosporium* infection of the oak and sycamore. It should be applied in late winter before the leaves have begun to appear.

A valuable preventive treatment for fungous infections of trees, in some cases at least, consists in burning the leaves each fall. This is especially valuable with *Rhytisma*, common to maples, for this fungus does not mature its spores while the leaves are on the tree, and burning the contaminated leaves would lessen the chance of infection.

Finally, attention should be given to keeping trees in a healthy condition. Countless examples could be given of the lessened chances of infection possessed by a healthy tree.

FIG. 70.—Elm tree showing pitted trunk associated with borers. Often observed on trees under uncongenial conditions.

WINTER INJURIES.

Injuries resulting from low temperature are common and often cause considerable damage to vegetation. Whether a species is native or introduced it is likely to suffer from winter injury if the proper condition prevails, but plants introduced from regions where the climate is mild are more likely to suffer from the effects of severe cold, although this does not always follow. Moreover, plants grown out of their customary habitats, or under uncongenial conditions, become more susceptible to winter injury. The red maple, for instance, which usually grows in wet places, becomes more susceptible to winter injury when grown in a dry situation, and the same holds true for other swamp species.

Winter injury is often restricted geographically, although during some seasons it may be quite universal. The same type of injury may also be more common, as well as more serious, in one locality than another. The effects of winter injury to trees may also be local, *i.e.*, only the

branches or buds or flowers will be affected; or, again, it may be confined to the roots or other portions of the tree. The apple, pear, quince, peach and plum, various shrubs and vines and small fruits are often injured severely both above and below ground from winterkilling, and much loss results to agriculturists.

FIG. 71. — Same as Fig. 70, with bark removed, showing characteristic sculpturing.

There are several types of injury resulting from low temperature which may be easily distinguished, and which occur almost every year, such as winterkilling of the roots, of the trunks, branches, twigs and buds; also injury to exposed roots; to the cork cambium, resulting in exfoliation of the outer bark; and frost blisters, causing subsequent defoliation.

Winter injuries are not always the result of severe cold, but follow from a combination of factors. Even the temperature of a comparatively mild winter is sufficient to cause much injury to trees and vegetation in general if the preceding summer and fall have been unfavorable for normal plant development. A very dry summer affects the normal growth of vegetation, and if a warm and unusually wet fall follows such a period the plant will go into the winter resting stage under abnormal conditions, and may therefore possess little power of resistance to cold.

Some of the conditions which underlie winterkilling are as follows: —

Severe cold, causing frost to penetrate to a great depth.

Sudden and severe cold following a prolonged warm spell in the fall, in which case the wood tissue is tender and immature.

Conditions which favor a soft growth and immaturity of wood. Various causes may be responsible for this, such as growth in a low, moist soil, too heavy manuring or fertilization, or absence of sufficient sunlight.

General low vitality, caused by insect pests and fungous diseases and lack of moisture in the soil.

Insufficient soil covering, such as lack of organic matter, light mulching and snow covering in winter.

Location in unusually windy and exposed places, etc.

Winter Injuries of Roots.

During the past decade an unusually large amount of injury has occurred to trees through the northeastern portion of the United States as a result of root killing. Innumerable orchards, small fruit plantations and various ornamental plants have suffered, and forest and shade trees form no exception. This injury has been more severe in New York and Ohio than in New England. The trees most severely affected by root killing are the white pine, black oak, white oak, ash, red maple, white maple, elm, butternut, etc.

There are many symptoms characteristic of this root injury which manifest themselves according to the extent and nature of the injury. If the entire root system is killed the tree dies rather quickly. Sometimes an effort will be made on the part of the tree during the spring, especially if a few roots are still alive, to produce foliage, but the tree soon dies. Then, again, a tree will mature its foliage fairly well, but as soon as the

FIG. 72.— Elm slowly dying from defective root system.

soil becomes slightly dry it will die. In such cases the leaves often turn brown and dry up, and remain on the tree in this condition. There are many cases in which the root systems are only slightly affected, when the tree may live for some time and only show a defective top. This slight affection of the root system is particularly common in red maples, which very often recover in a year or two, the only apparent effect being the somewhat smaller leaves found at the tree's crown. In more severe

cases the top of the tree fails to produce foliage, and the characteristic staghead effect is seen. (See Fig. 82.) We have observed elm trees 4 feet in diameter die suddenly from winter injuries to the roots, but more often death from root injury in elms is a rather slow process, the branches dying at the top and usually presenting the characteristic staghead appearance.

Elms and black oaks often show the results of root injury by tufted foliage effects, especially when much of the upper part of the tree is

FIG. 73. — Elm branch with tufted foliage, resulting from winterkilling. A large percentage of the branches on this tree are dead.

dead. The few remaining live branches produce numerous large leaves, — the result of an unbalanced relationship between the root system and the upper portions of the tree. In all cases of root injury those portions of the tree farthest away from the water supply, or, more properly, those which are in less direct communication with the main or principal channels of translocation or mobilization, are affected first. In trees naturally developing single leaders, such as the rock maple, the tops die back first, whereas in the elm, which has several leaders or branches located more or

less alike as regards water supply, each branch is likely to be affected similarly. In evergreen trees possessing a defective root system, sun scorch or burning of the tip of the leaves sometimes follows. This is often serious and may cause a loss of all the foliage, and later the death of the tree (white pine blight).

FIG. 74. — Winterkilled root from elm tree. Note lack of fine fibrous roots, which have died.

Many small fruits, grape vines, etc., quite commonly suffer from winterkilling of roots. Plants affected in this way will leave out in the spring, set their fruit and then usually die before it is matured, demonstrating that the maturing and ripening of fruit acts as a severe drain on the water supply of the plant. A fairly large number of shade trees located remotely, or near one another, have died from winterkilling of roots in recent years, necessitating considerable outlay in removing them. Trees located on embankments are very likely to winterkill, that portion of the tree towards the embankment being affected. Roots growing under favorable conditions are less likely to be affected than those growing under poorer conditions, even in case of a single tree. The smaller, younger feeding roots are usually most severely affected, and there is a marked tendency in some species for the roots continually to die back to the trunk when the terminal root system is affected. In these cases numerous new lateral roots are often formed, but as the dying back continues, these are eventually involved. Various fungi soon attack any part of a tree dying from root injury. Later, the bark falls off, but deterioration is not so rapid as in trees killed by other causes.

FIG. 75.—Norway maple affected with *Nectria cinnabarina* following winterkilling of twigs.

While the symptoms of dying back resulting from winterkilling of roots

are not alike in all cases, they are easily distinguished from those of troubles caused by other agents, such as gas poisoning, etc. In the majority of cases trees showing this staghead effect, whether from drought or winterkilling, die gradually, and even when their death is more or less rapid there are few of the symptoms characteristic of gas poisoning. Trees poisoned by gas usually die and disintegrate rapidly; also the diagnostic features to be found in the tissues of trees killed by gas are entirely different.

Winter Injuries above Ground.

There are numerous cases of injury occurring above ground from the effects of winter, such as the dying back of California privet, various fruit trees and vines, our native alders, white birches, the terminal twigs of trees like the horse-chestnut, Norway maple, sycamore, Japanese maple, and a considerable variety of exotic trees and shrubs. Some of the specific types of winter injury to trees will be best treated under the different names by which they are known.

FIG. 76. — Same as Fig. 75, enlarged, showing pustules.

Winter injuries, like other types of injury responsible for the production of dead tissue, are usually followed by various species of fungi, a common form being *Nectria cinnabarina*, characterized by the appearance on the bark of numerous cinnamon-colored pustules, — fruiting bodies of the fungi.

Frost Cracks.

Frost cracks are often seen on many of our shade and fruit trees in winter, and are particularly common to the elm and linden, although occasionally seen on maples. They extend down the trunk for some distance on the sunny side of the tree, and are caused by severe changes in temperature during the winter. Some of our forest trees are also subject to frost cracks; *e.g.*, the striped maple when planted in the open, but never in the dense forest, its native habitat, showing that the trunks of certain trees need to be shaded. Frost cracks open in winter and close more or less in summer, although quite often they never succeed in entirely healing over. In the spring they usually bleed profusely, giving forth a sour, dingy-colored sap called "slime-flux," which shows under the microscope various species of fungi, algæ and yeast.

The opening and closing of frost cracks vary with the temperature, barometer and relative humidity, and so closely is this variation allied with meteorological factors that the weather conditions can be deter-

mined quite accurately. Sometimes frost cracks open 4 or 5 inches or more in winter and close pretty well in summer. They usually extend rather deeply into the wood.

The best way to treat frost cracks is to staple them together. (See Figs. 77 and 78.) Since the cracks open more in cold weather than in warm, this operation should be done in the spring or summer, when the cracks are more or less closed. Staples made from iron three-eighths to five-eighths of an inch in diameter and 4 to 5 inches wide, with prongs of the same length, are best suited to this purpose. The size of the staples depends upon the nature of the frost cracks to be treated. In making up the staples it is a good idea to have the ends of the prongs bent inward a trifle, as they are more likely to hold. The staples are driven into the tree at a distance of from 15 inches to 2 feet apart, as the case requires, and this is best done by first boring holes about the size of the staples. The bark and wood should be removed sufficiently to allow the staples to be driven in flush with the wood, and the exposed tissue should be treated with some antiseptic substance, such as paint or creosote. If it becomes necessary to treat the cavity of the frost crack it should be done in the winter when the crack is open, and such materials as creosote, coal tar and elastic cement or oakum may be employed for this purpose. Disinfecting the wood is a most important treatment, but filling the crack is of secondary importance and is not absolutely necessary. In our experiments the use of staples in large trees has been successful in holding the crack together so that healing of the tree may follow. If the cracks are not held securely together their constant opening and closing, due to the changes of temperature, rupture the healing tissue and prevent the callus from joining. Trees are sometimes so severely injured by frost cracks that they bleed to death, and we have observed maples that had bled to death in a few weeks from this cause. Occasionally the cracks extend from the very top of the tree down to the base, when there is small chance of the tree surviving.

FIG. 77.—Effective method of treating frost cracks by iron staples. (See Fig. 78.)

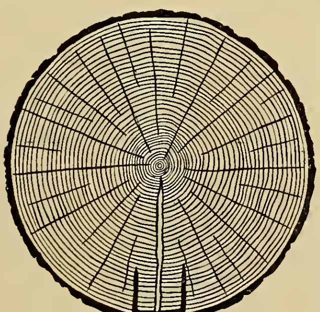

FIG. 78.—Section of tree showing frost cracks and iron staple method of preventing opening, thus facilitating healing.

Winterkilling of Cork Cambium.

As already stated, the effects of low temperature on a tree may be entirely local; *i.e.*, it may affect some particular organ or some one portion

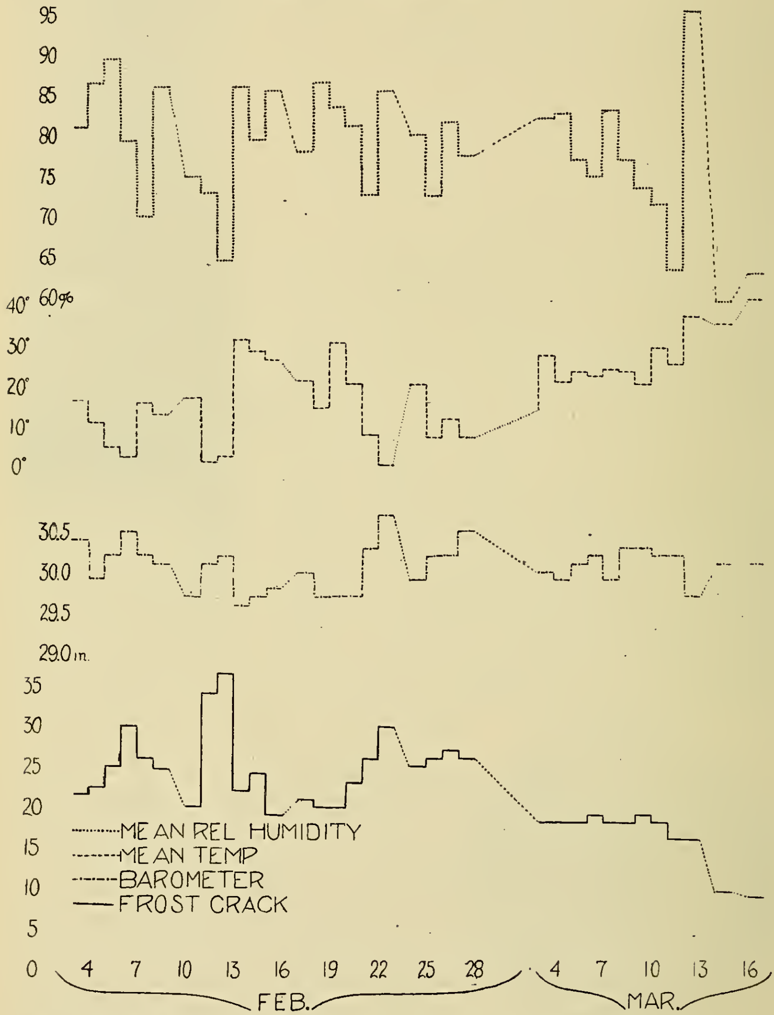

FIG. 79.—Showing curve of opening and closing of frost cracks in elm trees. The lower curve represents the variations in the opening and closing the others represent the mean relative humidity, mean temperature and barometer in the order named.

of the tree only. Following one of our extremely severe winters a few years ago, elms and some sycamores were found suddenly discarding their outer bark, — a rather unusual phenomenon. This loss of the outer

bark was brought about by winter injury to the cork cambium, a vital layer located between the outer and the inner bark. It did not injure the tree in the least, since the inner bark and the cambium layer underneath remained unaffected. As the collapsed cells of the cork cambium decomposed, the outer bark became loosened from the tree and fell off in a year or two, covering everything it happened to fall upon with a peculiar reddish powder. A microscopic examination of this powder showed it to consist of disintegrated cork tissue, or lamellæ. This injury to cork cambium from low temperature, although observed here and there, was not common. In one city in New York, however, 50 trees were affected, but in only one or two instances did injury extend to the wood and involve the cambium layer. One large sycamore tree 4 feet in diameter, which we observed, lost all of its outer bark, but is in good condition at the present time. The large section of bark, composed of many annual layers of cork, fell off in a comparatively short time, giving to the trunk an unusual whitish appearance. Occasionally there may be found in our State elm trees in which the cork cambium has been affected by winter temperature, resulting in a subsequent loss of the outer bark. But the exfoliation of small portions of the outer bark of elm trees is not uncommon, and should cause no apprehension.

FIG. 80. — Elm tree which has lost its outer bark, resulting from winter injury to cork cambium.

Sun Scald.

Sun scald is a type of injury affecting unripened wood. It is quite commonly met with on rock maples and orchard trees and on some of our wild shrubs. Shade-loving trees are particularly susceptible to sun scald, as may be observed in any forest clearing. For instance, the moose maple, a shade plant, seldom scalds in its native habitat, but when timber is removed and the sun allowed to enter, it is affected. This tree is undoubtedly the most susceptible of any to sun scald.

On the apple sun scald is often associated with canker (*Sphæropsis*). White pines also, when thinned too freely, will sun scald severely on the trunk. Many shade trees in our State show injury from this cause, the trouble being more common in some localities than in others. In one section of a city in the eastern part of the State more than 60 per cent. of the maples were found to be suffering from sun scald. The scars, which were confined to the trunk, were invariably on the sunny side of the tree,

being more commonly on the southwestern side, where the maximum temperature was usually found.

Sun scald does not usually involve the whole trunk of large trees, but in many cases, particularly small maples, the whole tree will suffer. A few years ago, in a comparatively short distance on one street, 16 maples had died from sun scald, and at one time our wild cornel (*Cornus circinata*) suffered severely from this trouble, many of them never recovering.

Quite often young rock maples will show only small spots affected by sun scald, proving that the injury may be only local, as in the case of the apple, on which tree sun scald often takes the form of collar rot. Sun scald on apples is often confined to the shaded branches, and sometimes occurs on severely pruned or dehorned trees.

FIG. 81. — Fungi following attacks of borers on rock maples, resulting from extreme drought.

In some cases sun scald will be found on tree roots and root buttresses exposed by regrading. Instances of this class of injury have been noted, particularly in the case of hickories. Any regrading necessitating the exposure of roots should be done in the spring rather than in the fall. Piling soil too high around the base of young apple trees produces injury, and frequently results in girdling the trunk and the death of the tree.

Most cases of sun scald are followed by an outbreak of *Nectria cinnabarina*, as is often the case with winter-killing. The treatment of sun-scalded areas should consist in scraping the wood, after removing the bark, and treating with some such antiseptic or preservative material as creosote and coal tar, or thick paint.

DROUGHT.

The unprecedently long period of drought of the past five or six years has been an unusually severe drain on vegetation in general. While the rainfall records for this period show quite a marked falling off from normal, it should be borne in mind that rainfall is only one factor in producing drought, and the amount of rainfall seldom gives a correct idea of the severity of drought. So far as crops are concerned, the amount of water contained in the soil is a most essential factor. This is determined not only by rainfall but by the amount of water withdrawn from the soil by surface evaporation and the transpiration of plants. Enormous quantities of water are removed from the soil by these processes, which are much influenced by sunshine and wind. The amount of water transpired by the foliage of trees varies greatly from day to day. When the meteorological conditions are favorable for this function, as they usually are during hot, dry seasons, enormous quantities of water are taken from the soil into the air; consequently the soil may contain much less water than rainfall records would indicate.

One of the common effects of drought on trees is the premature yellowing and falling of the leaves. Quite often, however, as in the case of the elm, the leaves fall off in large quantities without turning yellow, and the not unusual habit of this tree of shedding its terminal branches may be associated with drought. During dry periods the leaves of rock maples often sun scorch, particularly when strong winds are blowing; and what is known as bronzing of the foliage is associated with a lack of water.

Drought in summer interferes with the development of the tissue, thereby affecting the growth of trees. In times of unusual rainfall a renewed activity often takes place in the fall, when many shrubs will begin to blossom again and throw out new leaves. The result, especially in very cold winters, is a susceptibility to winterkilling on the part of the tissue.

FIG. 82. — Showing maple with staghead effect.

Drought is responsible for many pathological conditions in trees. Many of them, such as the rock maple, the European cut-leaf birch, the white ash and others, become weakened and therefore more susceptible to attacks from borers and in some instances to scale insects, as a result of which many trees die. When plants enter the winter resting period after a drought in the fall they are very likely to become victims of winterkilling.

Severe drought affects the roots of trees, which are unable to thrive with so little soil moisture for any length of time, especially when the soil is dry as powder to a considerable depth. During the past three years the root systems of numerous maples, elms and other trees have been severely affected by drought, as shown by the cases of staghead and the unusually large number of trees that have died during this period. Trees affected by severe drought sometimes die suddenly, but more often they linger in a dying condition for a few years. The wood of trees like the elm, when dying from drought, is invariably quite brittle, owing to the fact that the decreased water supply from the roots causes a transformation of the sapwood into hard wood.

Shade trees growing in dry situations may be greatly helped over periods

of drought by cultivating around them, by supplying water, or by turning under the sod and applying manure heavily. Planting a crop around the tree is also beneficial, but when this cannot be done conveniently, water may be supplied to the roots through numerous holes 1 or 2 feet apart and 12 or 15 inches deep, driven in the soil by means of an iron bar. In applying the water it is important that the feeding roots be reached, and perhaps a small amount of plant food may be added at the same time. Sometimes wells are installed near the feeding roots of trees; and tile aqueducts can be placed under trees at the time of planting, through which water can be supplied to the roots of the tree. This latter method would prove valuable in periods of drought for trees like the European birch and others which are greatly weakened by any deficiency in the water supply.

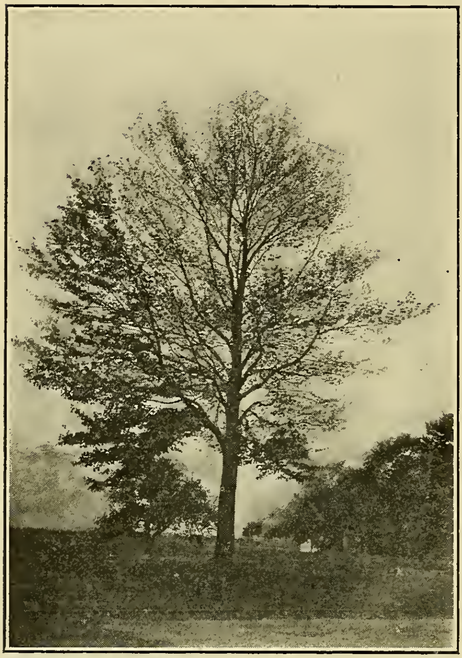

FIG. 83. — Red maple, alive with inferior foliage at the top.

SUN SCORCH AND BRONZING OF LEAVES.

Sun scorch is a physiological trouble characterized by the wilting and burning of the foliage of several species of trees during the spring and summer. Sun-scorched leaves often present only a few dead, brownish areas located on the margin of the leaves, or comprising more or less large areas of dead tissues between the leaf veins. When a strong wind is blowing the dead areas often disappear and the leaves present a lacerated appearance.

Sun scorch is caused by severe warm winds when the soil moisture is low. It is more common in the spring and early summer, when transpiration is at its maximum, the leaves transpiring more water than the roots can obtain from the soil. As a result they become wilted, and those parts of the leaves which fail to recover from the wilt die. Identical troubles affect agricultural crops, ornamental shrubs, etc., although known by different names. Tipburn of potatoes and onions, topburn of lettuce and

the so-called winterkilling of conifers and rhododendrons in the spring are in reality sun scorch.

The rock maple is most commonly affected by sun scorch, although other trees suffer to a certain extent. There is seldom a season that this species does not sun scorch, and during the summer of 1913, 30 per cent. of the trees in some localities were sun scorched so badly that the foliage presented a decided reddish brown appearance.

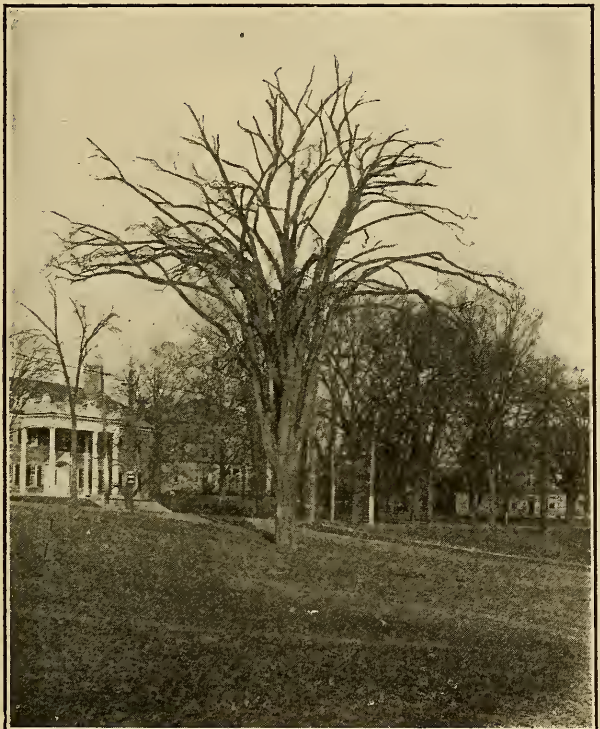

FIG. 84. — Elm tree showing staghead from defective root system. Note dead, stubby branches at the top.

As already stated, strong winds are one of the prime causes of sun scorch. A few years ago in May there was a wind from the northwest which blew at the rate of 71 miles per hour, and as a result many thousands of rock maples sun scorched throughout the State. Burning in all cases was confined to the northwest side of the tree. The particular winds which cause sun scorch may easily be ascertained, for that part of the tree exposed to the prevailing winds is always the one affected.

Some trees are subject to sun scorch each year. Light, porous soils having little water-retaining capacity are responsible for a great deal of

this trouble, as shown by the fact that the white cedar, arbor vitæ, etc., accustomed to wet situations, are quite susceptible to sun scorch when grown out of their natural habitat. There is also reason to believe that in some cases a peculiar chemical condition of the soil or some variation in the root absorptive capacity, which limits absorption, is at the root of the trouble.

We have been observing for a long time maple trees which sun scorch badly each year. During especially severe droughts every leaf is affected, while trees located near by are not in the least injured. The leaves of trees suffering from sun scorch do not usually fall off, but remain alive, although discolored. It is impossible for them to perform their full functions, but little injury results to the tree.

Rhododendrons, arbor vitæs and other conifers often burn in the spring before the frost is out of the ground, when strong, warm, dry winds occur. When they are mulched the frost remains in the ground longer than it otherwise would, and the winds cause more transpiration of water than the roots can supply. Many rhododendrons meet their fate in this way, their death usually being attributed to winterkilling. This can be prevented by removing the mulching early in the spring and allowing the sun to thaw out the frost.

"Bronzing" of foliage is merely another form of sun scorch common in very dry, hot periods. It is not caused by wind, and there is no laceration of the foliage. Examination shows that the cells near the veins and veinlets of the leaves are alive, but those farthest away are dead. This bronzing is caused by a lack of water supply to the cells of the leaves located most remotely from the veins or source of water supply. Like sun scorch, it is associated with excessive transpiration and diminished root absorption. The leaves become a reddish brown or bronze color, the dead tissue giving them this peculiar hue. It is most commonly met with on the rock maple, though other trees sometimes show the same trouble.

Mechanical Injuries.

Although trees possess quite a remarkable power of growth, by means of which they are able under certain conditions to overcome apparently insurmountable obstacles, they do not always make use of this power. When roots and other organs are restricted in some way in their growth, they often lift objects weighing many tons, but when there is opportunity for active tissues to flow around the object, as it were, this more practical and easier method is used. Every type of injury to a tree acts as a stimulus, hence there usually follows an accelerated growth of the tissues around the wounds, which often produces disfigurement.

Under the heading "mechanical injuries" may be described many injuries arising from various causes. The injuries due to wires have been treated in Bulletin No. 156. In cities and towns perhaps one of the most common injuries to be seen on roadside trees is that caused by horses' teeth. Trees located between the sidewalk and the road are

especially liable to be gnawed by horses, but the many good types of tree guards to be had make most of this inexcusable. There are statutes which cover such cases of injury, but it is always better for the tree warden or city forester to prevent injury by the use of a tree guard than by resort to courts. Very often trees are injured by being so close to the roadbed that heavy teams come in contact with them and cause abrasions. This is common in large cities where there is a great deal of heavy traffic. Runaways are also responsible for occasional injury, and for all these reasons the ideal location for a street tree is that known as a "tree belt." Many of the modern streets are now provided with tree belts 4 to 10 feet wide or more, situated between the sidewalk and the road. When such space is available it is possible to plant trees some distance from the curbing, preventing injuries from heavy teams and horses' teeth. The most frequent offenders are grocerymen and marketmen. It is their common custom everywhere to leave their horses unhitched in front of a house, within easy reach of any trees located near the roadside. Tree-belt planting prevents this difficulty. If tree belts are not available, it is advisable to plant the trees inside the sidewalk near the highway line, and since on every well-kept avenue there are fertilized lawns, a tree in such a location is under desirable conditions for healthy growth.

FIG. 85. — Elm trees with bark scraped, illustrating a hideous and useless practice.

FIG. 86. — Obliteration of signboard on tree, resulting from stimulated callus growth.

Placing signs on trees is another objectionable feature. Since the signs cannot accommodate themselves to the tree's growth, the bark grows over them, causing ugly scars. The same objection holds true of the fastening of other objects, particularly wire fences, to trees.

Some injury to trees is occasionally caused by spurs. Trees have sometimes been severely injured in this way, and as a rule all climbing of

trees should be done without the use of spurs. Most of our intelligent and thoughtful foresters and tree wardens never allow them to be used.

Ice is responsible for much disfiguration of trees which cannot easily be prevented. It affects more particularly such soft-wooded trees as the white maple, and greatly mutilates them by breaking down their limbs.

Posting advertisements on trees on country roadsides is another objectionable practice, but this is prohibited by law in Massachusetts. (See page 263.) A great many roots are injured and destroyed by the

FIG. 87.—Trunk of an elm tree, showing old trunk and new formation of roots.

laying of gutters and curbs, sewers, water and gas pipes, telephone conduits and catch-basins, but at present this seems to be unavoidable.

Earth Fillings around Trees.

The remodeling and regrading of streets, lawns, etc., often necessitate filling in around trees. These earth fillings are usually fatal to trees, no doubt owing as often to the effects of the earth on the bark as to the lack of air to the roots from the deep covering of the soil. We have seen trees growing on a bank with one side of the root system and part of the trunk covered with soil. Those parts covered with soil gradually died, and finally the whole tree died. The maximum depth of soil around the trunk was not more than 8 inches, but the roots were covered for 18 to 20 inches. The soil used for refilling was of a fine texture, — undoubtedly

more injurious than a loose-textured soil would have been. In this case the death of the trees was caused by too close contact of the soil with the bark. When a stone wall is first built around the tree at sufficient distance to allow for future growth, to keep the soil away from the trunk, trees filled in to a height of 5 or 6 feet have been known to survive for many years.

Fig. 88. — Red maple injured by earth filling 1 foot deep.

Some trees are undoubtedly more easily injured by earth fillings than others, but building a wall around them to keep the dirt from the trunk, or even the use of cobble stones, brick or coarse gravel close to the trunk, tends to prevent injury. Banking soil for even a few inches around young trees sometimes causes injury.

There are many instances where trees which have been buried partly up the trunk threw out a new root system nearer the surface of the soil. The tree shown in Fig. 87 had been filled in with soil to a depth of 4 feet thirty-five years ago, and in removing the tree it was found that the old stump and roots were all decayed, but the new surface roots had proved sufficient to support the tree.

Fig. 89. — Wall built around the base of a tree to prevent injury from earth filing. (See Fig. 88.)

Bleeding of Trees.

A great many trees suffer from bleeding from different types of injury such as borers, lightning strokes, frost cracks, splitting of the trunk, and occasionally linemen's spurs. Often trees filled with cement bleed; and the exudation, containing magnesium compounds derived from the cement together with various microörganisms which thrive in the exuded sap, gives an unsightly appearance to the bark. Bleeding to excess is very injurious. Sometimes the death of trees from this cause is sudden, and in other cases the tree will linger, gradually dying back at the top, and eventually dying. The exuded sap, or "slime-flux," sometimes proves detrimental to the living tissue, as shown by the presence of saprophytic fungi.

Elm trees often show a white streak on the bark, caused by some injury resulting in bleeding, and maples are also quite often affected, sometimes going into a slow decline, followed by death from bleeding alone. These injuries are a difficult class to treat, and at present no satisfactory method is known.

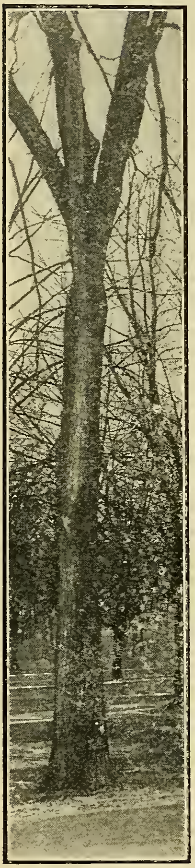

FIG 90. — Bleeding elm. The white streak on the limb and trunk shows the slime-flux.

Injurious Chemical Substance.

Kerosene Oil.

Many different oils have been used for spraying insect pests, some of which have proved reliable and others injurious. Kerosene oil can be used on some plants under certain conditions without causing injury, while in other cases it will kill them. A few years ago there was placed on the market a spraying device for the mechanical mixing of kerosene and water in different proportions, but when these materials are mixed mechanically they separate on the tree, and they have been responsible for the death of many trees. The oil soaks into the bark and often reaches the cambium and sapwood, destroying the tissue; and we have seen quite a few shade trees killed by spraying with kerosene and water to exterminate woolly aphis. In some cases every part of the tree touched by the kerosene was injured, while in others the injury was only local, a more commonly noticed condition on thick bark trees, while the former case was invariably restricted to trees with thin bark. The bark of trees killed by the use of kerosene presents a different appearance and develops usually a different type of fungous flora from the bark of trees dying from other causes; besides, traces of the oil, which remain on the tree for a long time, can be detected by the sense of smell. A fair diagnosis of this type of injury may be made from specimens of the bark, but when there are comparatively slight local injuries it is best to examine the tree *in situ*. Even slight traces of oil may be detected by removing small portions of the outer bark on the sunny side of the tree, the sun's heat causing a slight volatilization and perceptible odor.

Gas Oil.

Gas oil, a heavy oil used in the manufacture of water gas, is very injurious to trees when used as a spray. A few years ago several hundred shade trees were severely injured in one of our eastern cities by spraying

the trunks with this oil to kill clusters of gypsy moth eggs, it being used without any knowledge of its adaptability to this purpose. (Fig. 91.) The oil quickly soaked into the bark, cortical tissue and cambium, and in some cases extended into the sapwood for one-half to three-fourths of an inch. This injury occurred even on trees with fairly thick bark, killing all the living tissue wherever the oil was applied. While in some instances the trees did not show extensive injury, in others the trunks were 50 to 90 per cent. girdled, and many of the trees died from complete girdling. The most striking feature of this case was the ability of the trees to produce perfect foliage even after serious injury had taken place. One tree was examined whose trunk was girdled for a height of 15 to 20 feet, but this tree persisted in producing foliage for two years after the bark had fallen off. An explanation of this remarkable case consists in the fact that the heavy oil soaking into the sapwood prevented it from checking or cracking, therefore the supply of water from the roots was uninterrupted. The trees treated were elms, different species of maples, which are especially susceptible to injury, and others. The presence of oil in the sapwood in the cases cited above was of the greatest aid in preventing cracking and in helping to maintain the transpiration current and normal foliage, and this bears out the recommendation that tree wounds, very soon after they are formed, should be painted or treated in some way to prevent cracking. It is sometimes necessary to scrape the wound before applying the paint.

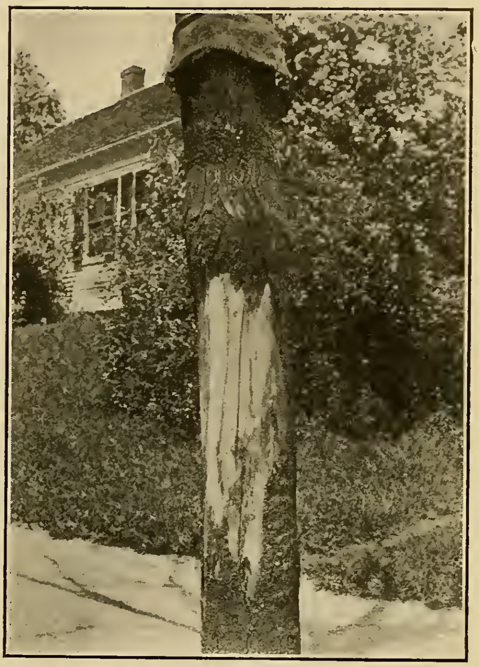

FIG. 91.—Effects of spraying heavy oil on trees. The oil penetrated the bark and killed the tissue.

FIG. 92.—Maple injured by burning leaves near the base of the tree.

Paint.

Ordinary house paint, although a crude enough treatment, has sometimes been used by ignorant persons on smooth bark trees, with, of course, resultant injury.

Miscible Oils.

Occasionally commercial oils used for spraying fruit trees for the San José scale cause local injury, and some shade trees have been known to be affected by their use. This is especially true of maples, and it is never safe to use oils of any sort on many smooth bark trees.

Road Oil.

Oils and other materials to keep down the dust in roadbeds are now much in use, and we have observed some injury from this source when the trees were located close to the highway and the buttresses of the roots were exposed. The roots are much more susceptible to injury from various causes than are the trunks, as they are not so well protected by bark, and when oil sprinkled on a roadbed touches some of the exposed roots it kills the tissue. Particles of dust from oiled roads which sometimes alight on the foliage of trees are said to cause injury, but this type of injury is rare with us. Whether the oil ever penetrates deeply enough into the roadbeds to reach the root systems of trees is not as yet known, but if it does it may cause serious injury. Neither are there specific cases of injury to the roots of trees by the dripping of oil and gasoline from automobiles, although if this leakage were sufficient it might reach the roots and cause injury. Not long ago, however, our attention was called to a tree supposed to have been killed by gasoline leakage from a near-by garage.

Creosote.

This material is used extensively on trees for disinfecting cavities, and, mixed with lampblack, for painting gypsy moth egg clusters. It does not appear to penetrate to any great extent when combined with lampblack. We have examined a great many trees to discover injuries from its use with no success, except in the case of linden roots, which had been exposed by regrading, where the underlying tissue was injured. But such instances are rare and the injury purely local in character.

In one case a combination of creosote and naphtha applied to a large number of trees for the destruction of gypsy moth caterpillars appeared to soak into the outer bark, apparently killing the cork cambium, which later resulted in a disintegration of the tissue. Whether these substances did further injury to the tree we were not able to learn.

Coal Tar.

Coal tar is much used for painting wounds and scars caused by pruning, and sometimes injures delicate tissue when first applied. The injury, however, is not serious, as shown by the fact that various saprophytic

fungi will develop where the coal tar has been put on. After coal tar has been on for some time it is evidently not injurious, even to delicate tissue.

Salt.

Salt used on sidewalks, in gutters and on trolley lines in winter has been known to cause injury to the root systems of trees. In one instance we noted injury to several small maples growing near a sidewalk and gutter which had been treated heavily with salt. In some cases where salt had been used extensively on trolley tracks, injury to trees was observed. It should not be used near valuable trees.

Other Injurious Factors.

Arsenate of soda, potassium cyanide and other chemicals are extremely poisonous to trees, and when placed in holes bored in the tree the two first named will soon cause death. Since arsenate of soda is often used as a weed killer, it is recommended that care be taken in applying it around the feeding roots of trees.

A quite common opinion among linemen is to the effect that copper spikes driven into trees will kill them, but a small maple so treated by us a few years ago showed no abnormal symptoms.

The foliage of different trees is often injured by spraying with various fungicides and insecticides. It is well known that plum and peach foliage is quite susceptible to this type of injury, and even the leaves of maples and other trees may be injured by arsenate of lead. The extent of the injury depends not only on the nature of the spraying solution or mixture used, but also on the condition of the foliage sprayed. We have observed injury to maples from the use of 12 pounds of arsenate of lead to 100 gallons of water; and Paris green, owing to its present-day uncertain composition, often burns foliage.

Burning insect nests with torches, although a common practice, is a bad one, and invariably causes injury. Serious harm often results from burning leaves and grass around trees, and the roots of forest trees, which are often close to the ground, are sometimes injured by burning the underbrush.

In conclusion it may be said that in any treatment of trees one should always have before him some definite object; he should leave strictly alone the numerous irrational methods constantly being advocated, or apply to them first the measuring stick of common sense.

Banding Substances.

During the past fifteen years a large number of banding substances have been placed on the market, all of which with one or two exceptions have proved injurious to trees. These substances usually contain some oil which affects vegetation injuriously, in some cases even when applied over tarred paper. The injury caused by banding substances varies

greatly, the tree often being completely girdled, and again only a local effect is produced; *i.e.*, portions of the tissue here and there will be affected by the material. This results in relieving the tension of the tissue at places, and an abnormal growth of the tissue follows.

"Tanglefoot" appears to be the only substance that does not cause injury when applied directly to the bark, *i.e.*, when tarred or other heavy paper is not used. Many laboratory samples of substances resembling "Tanglefoot" have been made up, but in only one instance have any of these materials resembled "Tanglefoot" in virtually all its properties; at least, among those which have come to our notice. While the injuries from banding substances have been quite pronounced, practically all of the substances causing injury have now been discarded.

An examination made by the writer of many trees treated with the so-called "Tanglefoot" has revealed only one case of girdling, and even in this case we were not able to obtain any clue to the manufacturer of the particular material causing the injury. This substance, although resembling "Tanglefoot," may have been one of its many imitations some of which are known to cause injury. The only other case of injury from "Tanglefoot" was where it had been applied to the trunk at the same place for a number of years. The oil seemed to penetrate the outer bark to some extent, affecting the texture of the bark; but this injury is not serious, so far as we have observed, and can be prevented by changing the location of the band occasionally. We have never noticed any injury from the use of "Tanglefoot" to the cortical tissue or cambium located underneath the bark. Our previous experiments show that the most delicate tissue was not injured when it was applied to various plants. But injury was noticed to smooth bark trees when other banding substances were applied, even on tarred paper. Tarred paper alone is capable of injuring the bark of some trees, and the injury mentioned above may have been caused in this way in some cases.

Effects of Illuminating Gas on Trees.

A much larger number of trees suffer from the effects of escaping illuminating gas in the soil than formerly. The increased death rate from this cause may be accounted for by the fact that gas is now more extensively used, and the larger pipes and different types of connections employed, together with the changes in the methods of laying and calking the joints, also play their part; at least there is much less leakage from small pipes having thread joint connections, which have been in the ground for many years, than from larger pipes calked with oakum and cement or lead. Electric cars, steam rollers, motor trucks and other heavy traffic on highways are often responsible for defective joints and the consequent leakage of gas, especially in newly installed lines. Also, the continual undermining of gas conduits made necessary by the construction of sewer and water lines, as well as the effects of frost in very cold winters,

cause leakage; and, finally, the wires, steel rails, etc., carrying electricity are a constant source of danger to gas pipes, as is occasionally proved by cases of electrolysis.

A large amount of the gas manufactured is unaccounted for, often averaging 10 per cent. This loss may be accounted for in part by discrepancies in meter readings, etc., and should not be laid wholly to leakage, and a small percentage of unaccounted-for gas is of slight importance. It should be stated in justice to many of the large gas producers that every effort is usually made to prevent leakage and injury to trees. Some of the most progressive manufacturers spare no expense in constructing and maintaining their lines, although it must be confessed that there is great need for improvement in methods of conveying this dangerous substance. The larger pipes, which are more difficult to keep calked securely, furnish better facilities to patrons; nevertheless the danger from leakage is greater. There are numerous connections in gas mains from which the leakage is slight, perhaps only a few cubic feet a day, while in others it is very great. Even small leaks, if neglected, will injure trees in the course of time, owing to the gradual saturation of the soil with gas.

FIG. 93.—Maple tree dying from the effects of illuminating gas, with characteristic fungous (*Polystictus*) growth.

There are several kinds of gas used for lighting and heating, *i.e.*, water gas, coal gas, gasoline gas, acetylene gas and others, but their effects on the plant are quite similar, and they are all very poisonous to vegetation. The poisonous properties are largely confined to the numerous products absorbed in small quantities by the soil moisture, taken up by the roots and translocated through the tissue. The reactions to the substances are not quite the same in different locations nor in different species of trees. Trees poisoned by illuminating gas usually show some characteristic post-mortem symptoms, but the problem of diagnosis is greatly complicated by the fact that many of these symptoms may be found in trees dying from other causes. More or less rapid deterioration and increased brittleness of the wood are quite characteristic symptoms, however.

In summer, the first effects of gas poisoning may be seen in the foliage. The leaves often turn yellow and drop off, while in other cases the leaves will fall when still green, and, again, the leaves will turn a reddish brown and die without falling. The upper part of the tree, being far from the source of water supply, usually shows the effects of defoliation first. These various symptoms occur before there is any evidence of abnormal tissue above ground. But after the water in the soil containing the poisonous

gas principles has passed up through the roots and stems, the sapwood, cambium and bark become abnormal. The first symptoms take the form of a characteristic dryness of the cambium and other tissues outside the wood, this being the first indication of the approaching death of the tissues. Later, these tissues — cambium, phloëm and cortex — turn brown, and disintegration follows. The roots, which first absorb the poison, are naturally the first to become abnormal, but later, as absorption and translocation proceed, the poisonous constituents may be detected in the wood at the base of the tree. It not infrequently happens that the tissue here is dead, while that in the trunk a few feet above is alive, but this condition does not endure, the whole tree sooner or later becoming affected. When the underlying tissues die the tissue tensions are destroyed and the bark changes color, gradually growing darker, and its physical properties become greatly changed. Soon various species of fungi, such as *Polystictus*, *Schizophyllum* and others, find a foothold on the bark, and borers and other insects attack the dead tissue. Even bacteria and molds, like *Penicillium*, become active and hasten the process of disintegration. The smaller twigs become dry and brittle, and the ends often break off; the upper limbs usually lose their bark first, but eventually the larger limbs present the same appearance. Disintegration may take place so rapidly that in one and a half to three years the bark disappears and most of the larger branches break off, and soon nothing but a portion of the trunk and a few stubs remains.

FIG. 94. — Effects of illuminating gas on elm tree one and one-half years after leakage occurred.

It must be understood that many of the symptoms mentioned above may also be found in trees dying from other causes and do not necessarily constitute reliable guides to the detection of gas injury. The tissue furnishes the best symptoms for diagnosis, and the writer, who has for the past twenty years been examining hundreds of trees killed by gas, from the first found it necessary to make a thorough examination of the tissue to warrant any degree of accuracy in the diagnosis. He has

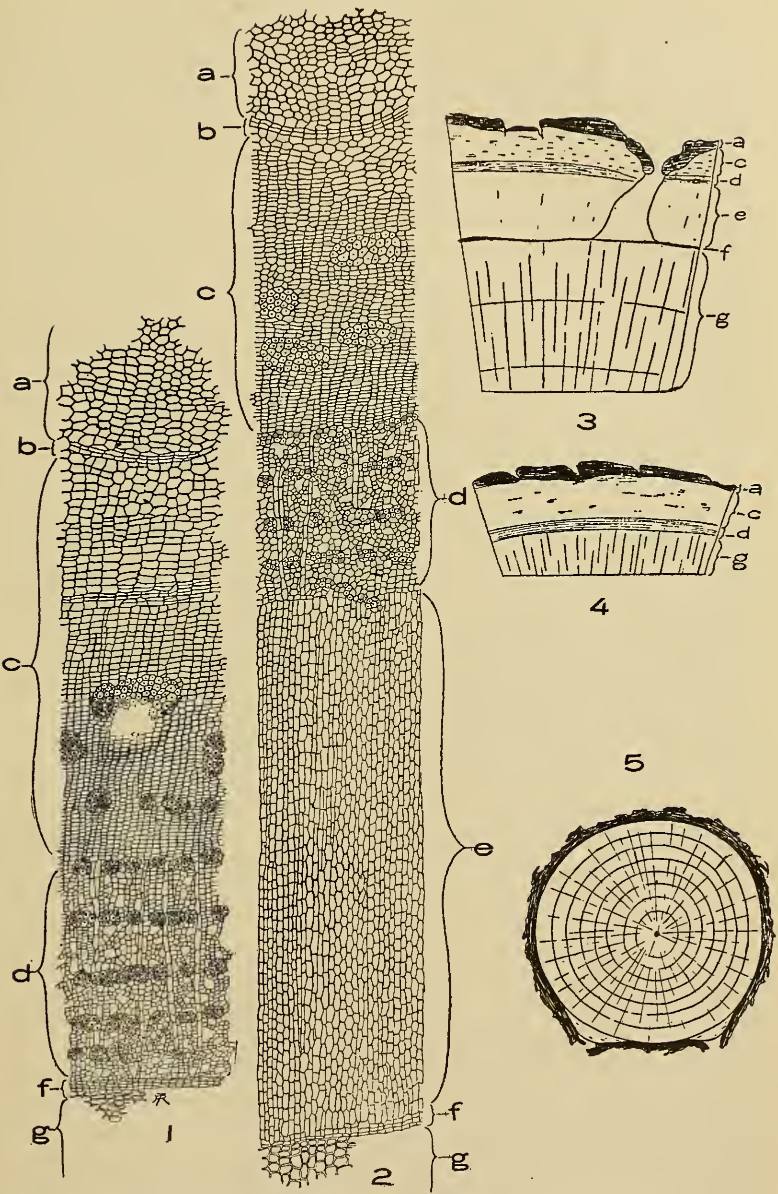

FIG. 95.—Showing cross-section of Carolina poplar (*Populus deltoides* Marsh). 1, Cross-section of normal stem, enlarged; 2, same, showing abnormal growth; 3, naked-eye view of same; 4, section of a normal stem; 5, cross-section of trunk of tree showing the splitting of the bark; *a*, bark; *b*, cork cambium; *c*, cortex; *d*, phloëm; *e*, abnormal parenchyma; *f*, cambium; *g*, wood or xylem.

also taken exhaustive notes on every symptom shown by trees dying from various causes, and from these notes may be had many interesting data on the relative importance of various symptoms. In diagnosing gas injury one must learn to detect either by chemical means or from direct observations and experience the presence of the poisonous constituents of illuminating gas which are absorbed by the roots and circulate to a certain extent through the tissues of the wood.

As already intimated, no two species of trees suffering from gas poisoning present precisely the same symptoms, and there is much difference existing in the same species, the location, season of the year and other factors having an important modifying effect. Trees, for example, when examined in the fall, will show slightly different symptoms from those examined in the spring. This is also true of trees poisoned by gas from different manufacturing plants, which varies considerably. The variation in the chemical constituents of the soil here and there may to a certain extent account for the variations in the reaction of gas on the tissues, but this factor is probably not very important, since these variations in the soil are likely to be found even in a single town supplied with gas from one source, and as a rule the symptoms of trees injured by gas from a single manufacturing plant are alike. Tables giving the results of gas analysis from various corporations, however, show that there is considerable difference in the composition of gas, and that gas from a single manufactory is likely to vary slightly from day to day, not only in the percentages of carbon monoxide and hydrogen, but in the other products.

The odor and color of the tissue should first be examined carefully when diagnosing a gas-injured tree, although it is possible by the use of chemicals to obtain reactions and to detect certain products in the tissue. There are different odors associated with the wood of trees which die from various causes, and it is therefore necessary to become familiar with these before relying too closely on this factor. For instance, molds and other micro-organisms found in the sap of trees dying from various causes often cause decomposition with resultant odors. But there will always be found in trees killed by gas peculiar characteristic odors difficult to describe, and more easily recognized, at least above the ground, after a tree has been dead for a few weeks or months. The odor is more prominent in moist than in dry trees, and can be detected in the tissues of the bark as well as of the wood. Sometimes this odoriferous wood is found deep in the sapwood, and can be recognized in the stumps of trees freshly cut, but in old stumps, where decay has set in, it is not always discernible. In such cases some part of the root system, if dug up, is likely to give a characteristic odor, except when the wood has become too dry and a more or less advanced stage of decay has set in. Even the rate of disintegration and the nature of the decay are often characteristic, and are of some value in diagnosis.

It should be remembered that the odors of different species of trees, even when in normal condition, differ greatly; *i.e.*, the natural odor of the

maple is quite different from that of the elm, horse-chestnut or red oak, and their products of decomposition also differ. The accurate diagnosis of trees killed by illuminating gas is highly specialized and technical. Nevertheless the characteristic odors given to the tissue by illuminating gas can be discerned quite accurately by one thoroughly familiar with them. Sometimes these odors are found in all of the tissues of the trunk, but more often they are confined to some special part of the tree or root. They are far more pronounced at the base of the tree, and rarely found in the top. Carolina poplars and willows often display peculiar reactions to gas poisoning. The bark splits open and large masses of soft, parenchymous tissue are formed directly from the cambium layer. When the tree dies this parenchymous[1] tissue decomposes into a mucilaginous mass. (See Fig. 95.) Some species appear to be less often affected by gas poisoning than others. It is a question whether there is much difference in susceptibility, however, as regards species. Trees like the elm and maple, with a large spread of the roots, naturally become poisoned if located near gas leaks, and some trees are adapted to more strenuous conditions and possess a greater capacity for regeneration than others, although they may be as susceptible to poisoning as trees of other species. Coniferous trees possess the greatest resistance to gas poisoning of any species, and in many instances they have been observed surviving in an apparently healthy condition when located dangerously near broken mains, while deciduous trees located much farther away would always succumb. In some cases where conifers have actually been poisoned to quite an extent they have completely recovered. This response may in part be explained by the protection furnished by the coating of micorhiza on the roots of conifers.

We know of no remedies which can be applied to trees already poisoned by gas, since the injury occurs below the surface of the ground, and the effects are seldom noticeable until the poisoning is more or less pronounced. If the leakage of gas could be discovered quickly and the leak repaired, the effects on the roots might be prevented, but this is rarely the case. Illuminating gas in small quantities acts as a stimulus to plants, and there is a certain capacity for adaptation to poisons possessed by them, although limited. By the time the effect appears in the foliage considerable gas has been absorbed by the roots, and since it is impossible to eliminate the gas from the soil, absorption is bound to continue and the tree is doomed. We have known of only a few instances (with the exception of the conifers above noted) in which trees have shown even slight symptoms of gas poisoning and survived for any length of time. In some instances where only one root has been affected, and the poison has not reached the trunk of the tree, amputation of the root may prevent further injury, and is known to have been effective. There are many cases in which trees have not suffered from gas poisoning although located near large leaks, owing to the amputation, during the installation of curbings, etc., of the larger roots which extended over the gas pipes.

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[1] Mass. Agr. Exp. Sta. Rept. 25, 1913, Pt. I., p. 51.

When the soil is charged with gas, digging it up and aerating it is beneficial, and in the case of severe leakage it is well to leave the trench open for a few days, if possible. On the other hand, boring holes in the soil and filling with water or lime is a perfectly useless practice. It is generally believed that if young trees are planted near others which have

FIG. 96. — Large elms killed by escaping illuminating gas, one and one-half years after leakage occurred.

died from gas poisoning, they will not live, but this is true only in some cases. If the soil is thoroughly saturated with gas, bad results will follow, but if the trees are planted in fresh loam and the old soil aerated, there is little likelihood of the tree dying.

Gas escaping into the soil from a leak follows the line of least resistance. For this reason, if leakage occurs in the street in front of a house, one can

often detect the odor of gas in the cellar, as the gas will follow the exterior of the pipe leading into the cellar, and often escapes into sewers, underground conduits, hydrants, etc. Wells are often badly contaminated even when located some distance away, and in the winter gas leakage becomes a source of danger to near-by greenhouses.

There is considerable difference in the resistance of soils to gas. In gravelly soils we have known gas to travel 2,000 feet when the ground was frozen and escape into the cellar of a house, while in heavier soils it is more likely to be restricted to smaller areas. It requires a considerable amount of gas to kill a large tree, although not so much as it would were

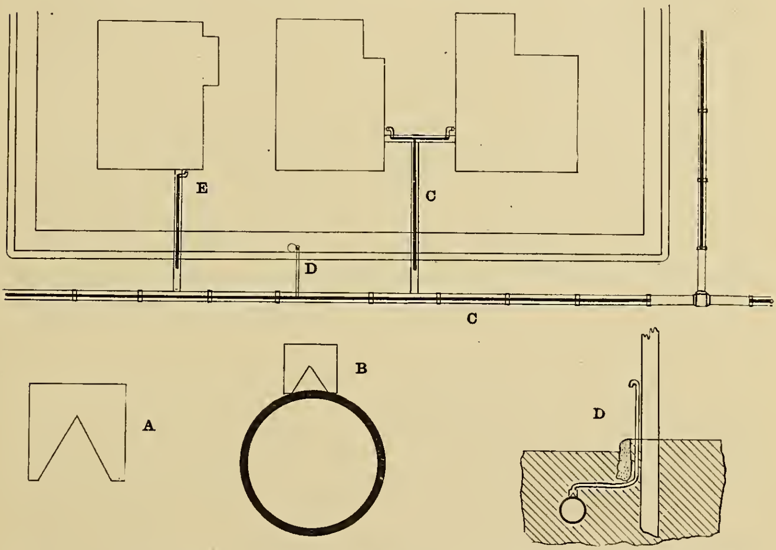

FIG. 97.—Protective arrangement against injury resulting from leakage of illuminating gas. A, cross section of protective conductor; B, adjustment of same to pipe; C, black lines showing method of arrangement of protective device on street and house service; D and E, vents for leakage.

it not confined so closely by the soil covers, especially in winter, and by the impenetrable macadam and other styles of modern roadbeds.

The danger to human life from illuminating gas is too great to be ignored, and even with the present defective systems of distribution it is not only possible but practicable largely to eliminate the dangers from this source to trees as well as to human life by the use of certain devices to prevent the leakage of gas into the soil.

The comparatively recent introduction of joints welded by the acetylene flame may prove superior to the threaded or calked cement and leaded joints in preventing leakage, but this system of laying street mains has not been thoroughly tested out in cold climates. There are also protective arrangements covering the pipes designed to prevent leakage of

gas. This protection may be secured by laying a simple device, originated and used by the writer, over the gas main to convey the leaking gas to certain points above the ground, thus preventing contamination of the soil. By using a block system or applying it to sections 100 or 200 feet long, as the case may require, and ventilating each section, a leak may be readily detected and repaired before it has an opportunity to cause any damage. The device made of chemically treated wood and shown in Fig. 97 is suitable for this purpose. It consists of pieces 2 inches square in cross-section and of any desired length. This size may be adapted to any size pipe and secured to it by wires at intervals of 6 to 12 feet (B). Each section, which may be 200 or more feet in length, is vented by means of a pipe running to a pole or tree or any convenient object (D and E), or may be vented directly over the pipe or near the sidewalk or curbing by using an ordinary iron shield provided with vent cap, such as is used for gas shut-offs. This takes care of all the leakage, conveying it into the atmosphere at certain points. If leakage occurs it can be detected by pedestrians and prevented from permeating the soil, where it would be likely to kill trees on the highway. While at present it may not be feasible to equip all pipe lines in this way, all new systems should be protected, and those already laid as fast as possible. This protection should also be extended to house services to prevent asphyxiation to human beings and injury to shrubbery and trees on private property.

Effects of Atmospheric Gases on Vegetation.

The atmosphere of industrial centers is a complex mixture of various substances. Besides the presence of the well-known gaseous constituents found in the atmosphere, — such as oxygen, nitrogen, carbon dioxide and water vapor, — hydrocarbons, solid particles and compounds of carbon, nitrogen, chlorine and sulfur are present in varying quantities. Argon, helium, krypton, neon, xenon and ozone are also found in the atmosphere in small proportions, but so far as is known they cause no detrimental effect to living organisms. Carbon dioxide, which is present in the atmosphere normally ranging from .03 to.04 per cent., is not destructive to living organisms at this dilution. On the other hand, it furnishes the most important source of food for vegetation, and plants will thrive even better with a much higher concentration than that normally existing in the atmosphere. Sulfur, which may be present in the air in several forms, constitutes one of the most injurious agencies to plant life, and sulfurous gases arising from smelters, which often contain other poisonous substances, are frequently detrimental to animal life. There exists some sulfur in most grades of coal, and during the process of combustion sulfur dioxide is given off. This pollutes the air to a certain extent, and if sufficiently abundant will injure plants. When oxygen combines with sulfur dioxide, it forms sulfur trioxide, which in turn forms sulfuric acid with water. Sulfuric acid is very corrosive, attacking and decomposing

various building materials, and is more or less injurious to plants and animals. The amount of sulfurous gases in the atmosphere, however, is often quite insignificant, and very exact methods of chemical analysis are required for quantitative determinations. The most exact and refined methods of analysis in use are hardly reliable for amounts less than 1 to 5,000,000 parts of sulfur dioxide. Particles of cement dust, such as may be found near cement manufactories, injure vegetation, as does the soot arising from incomplete combustion of coal. Moreover, dust particles, which may equal 50,000,000 to a cubic inch, form the nucleus of fogs, which in turn imprison various obnoxious gases, thus rendering the dust particles indirectly detrimental to vegetation.

Besides the injury to vegetation resulting from gases associated with smoke, smoke affects vegetation by causing a deposit of soot on the leaves, thus obstructing the light. The soot also clogs the breathing pores or stomata of the leaves, causing asphyxiation. The acids resulting from coal combustion which accompany smoke also affect the soil by producing soil acidity. At Leeds, Eng., a manufacturing city, it is estimated that the daily deposit of soot is about one-half ton, and in the vicinity of other English cities, where much soft coal is burned, the soil has become so impregnated with smoke acids as to be of much less value for agricultural purposes. Soft coal contains more sulfur than hard coal, and combustion is less complete, resulting in more smoke and solid particles, which are conducive to fogs. Fogs hold the sulfurous gases down, and in cities where considerable soft coal is burned such gases affect végetation more severely.

Soft coal is burned on steam railroads, but the escaping smoke and gases are readily dispersed in the atmosphere. Moreover, the exposure to gases of the vegetation along railroads is of such brief duration that injury to plants is seldom noticeable. Injury to trees is frequently discernible in the vicinity of railroad engine houses, or roundhouses as they are called. Soot is often found deposited on the trunk and foliage of trees in such situations, and the contained gases affect the size and color of the leaves.

Trees in general are affected by atmospheric gases, but some are much more immune than others. The black locust, Ailanthus and peach are especially so, while most conifers and some of the oaks are quite susceptible to injury. Many herbaceous and annual plants, such as morning glory, cosmos, ragweed, etc., are very susceptible to injury from gases. Short-lived trees of rapid growth, such as poplars, willows, box elders, cottonwoods and soft maples, will survive and resist smoke and gases more readily than the oak, elm, hard maple, chestnut and linden. Our native elm appears to be affected most seriously by atmospheric gases, although the nature of the symptoms resulting from constant exposure to atmospheric gases is such that few ever guess their true significance. The pathological effects following exposure to gases indicate troubles of a chronic rather than an acute nature, and the trees gradually lose vigor

through a series of years until they finally die. There are many instances in New England, particularly in large industrial centers, where the expectation of life of elm trees is reduced from one-half to one-third the normal, owing to the presence of noxious atmospheric gases, and no amount of soil renovation or tree surgery can correct these conditions.

It is questionable whether injury ever occurs to vegetation from smoke derived from wood, although in one or two instances injury to crops has been surmised. In each case the crops were located near brick kilns.

Lichens are the most sensitive organisms to smoke; although the smoke and gases derived from wood combustion appear not to affect them. These lowly organized plants are invariably absent on trees in cities, and in the thickly inhabited parts of towns where coal is burned, but may be observed in suburban settlements where wood is more used as fuel. These organisms are apparently affected even by the minutest trace of sulfurous gases in the atmosphere.

The greatest injury to vegetation occurs near smelters, where sulfur dioxide and other gases contaminate the atmosphere. In some places vegetation is affected 75 to 100 miles from such establishments. Where sulfur is used for bleaching purposes, and the atmosphere becomes polluted, vegetation is likely to suffer, and many manufacturing establishments which make use of coal-tar products, naphtha, ammonia, carbolic acid, creosote oil, etc., frequently fill the atmosphere with poisonous gases which injure vegetation and animal life. However, the manufacture of sulfuric acid by smeltering companies has done away with much of the injury formerly occurring to vegetation in their vicinity. In the manufacture of sulfuric acid the furnace smoke, which is heavily laden with sulfur dioxide, is used, and in modern equipments most of the sulfur contents are removed. Sulfur dioxide is much heavier than air, and possesses a pungent and characteristic odor. Persons familiar with the odor of sulfur dioxide are comparatively rare who can detect 2 to 1,000,000 parts when present in the atmosphere. Even 3 to 1,000,000 parts is detected by only few, while 4 to 1,000,000 parts is discernible to those of average sensitiveness.

The limitation of injury from sulfur dioxide to the most sensitive plants, or threshold of discoloration as we term it, is according to some experimenters 1 to 1,000,000 parts. This, however, is regarded as the theoretical limit; since it would require many hours to produce visible injury to the most sensitive plant with this concentration, and, as a matter of fact, burning or visible injury probably never occurs in nature with this dilution. Very sensitive plants will show discoloration when subjected to sulfur dioxide from 3 to 4 parts to 1,000,000 if they are exposed to this concentration for a number of hours. Or, in other words, to produce burning a concentration would have to exist in the atmosphere for some hours, even when present in sufficient quantity to be discernible to the sense of smell. Burning in general from various gases presents different appearances, and the same gas will produce entirely different pathological

symptoms even in the same species. Burning from gases in general is affected by light, soil and air moisture, and the age of the foliage constitutes a factor, as probably does the condition of the stomata or breathing pores of the leaves, which vary in number from 800 to 170,000 per square inch of leaf surface.

Some recent European experiments show that burning from gases is intimately associated with sunlight, a fact long recognized by American gardeners in connection with the fumigation of greenhouses. Fogs and mists are conducive to burning. As is well known, they have a tendency to drive gases downwards, imprisoning them, as it were, and preventing their diffusion. Burning even with the same concentration of gas is more severe in moist than in dry air. Southern exposures are the most favorable to burning from gas, as are the exposed tops of trees, where the light conditions are more intense, and it has been demonstrated that burning is associated with the assimilative activity of the leaf, which is at its maximum during bright sunlight. Hence, a plant in sunlight will show discoloration or burning at a much less degree of concentration of the gas than during cloudiness or darkness, and the proportions of sulfur dioxide in the atmosphere must be considerably greater to produce the same effects under poor light conditions than during sunlight.

As the stomata or breathing pores are open during bright sunlight and closed during dull days and darkness, these organs would appear to have some influence as regards burning. However, experiments have shown that the stomata or breathing pores of the leaves, at least in some cases, close immediately when exposed to various gases, and in this way they may prevent severe injury to a certain extent. The age of the leaf is very important as regards susceptibility to burning, the younger leaves not being so susceptible to burning as the older ones. This is shown by injury from illuminating gas in greenhouses. This gas affects the older foliage, while the younger leaves remain normal or unaffected with small dosages. This may be explained in two ways, *i.e.*, that the stomata of the older leaves which are injured are more or less inactive, whereas on the younger ones they are more active. Moreover, the assimilative processes more nearly approach their maximum condition in the well-developed or older leaves than in the younger ones; or, in other words, carbon assimilation is undoubtedly more active during June and July than during April and May in some species, and as burning is associated with the assimilative activity of the foliage, burning may naturally be expected to occur more severely to older leaves than younger ones. The probability of the inactivity of the leaf stomata constituting a factor in susceptibility to burning from gases is borne out by the fact that some species which possess thick and tough leaves appear to be the most susceptible to burning, and the inability on the part of the stomata to respond to external influences may be an important factor underlying injury from gases. The condition of the atmosphere is often extremely variable even in the same locations, and any gas would be variable in its concentration,

hence one part of sulfur dioxide per million might be present for a few moments at any particular point, while a few moments later only slight traces would be found.

The preparation of asphalt and tar on streets lined with shade trees sometimes results in burning of the foliage; and this is also true of steam rollers when employed for road work.

Sewer gas has often been suspected of injuring shade trees. The constituents of this gas are, however, extremely variable. Some of them are toxic, and in sufficient quantities are capable of injuring vegetation. As a matter of fact, however, injury to plants from sewer gas seldom occurs; on the contrary, sewers and cesspools furnish one of the best environments for root growth. Even when the poisonous gases of the sewers reach rather high percentages they are seldom produced in large enough quantities to do harm, and soon become diffused in the atmosphere.

In summarizing the effects of smoke on vegetation the following factors should be considered: —

Smoke is the product of combustion diffused in the air, and may be either visible or invisible, affecting vegetation in the following ways: —

By retarding growth and development of plants in consequence of the presence in the atmosphere of noxious gases, acids, etc.

By causing a direct burning of the foliage resulting from the gases present.

By causing asphyxiation through the deposition of soot on the foliage.

By reducing the light intensity and thereby affecting photosynthesis or carbon assimilation.

By constituting an important factor in the formation of fogs, which increase the susceptibility of plants to injury from gases.

By combining with certain soil constituents to form an acid soil, thereby affecting the roots of plants.

Smoke affects plants both directly and indirectly, although the effects are often slow in asserting themselves.

The direct effects of smoke arise from the products of combustion, such as soot and sulfurous gases, which affect the foliage and young shoots, also the soil, and, consequently, the roots of plants.

The indirect effects of smoke follow as a result of fogs, which are due to the solid particles present in the smoke and which also interfere with the normal light conditions, thereby affecting photosynthesis or carbon assimilation.

The factors involved in burning from gases may be classified as follows: —

1. Inherent susceptibility to burning, which is determined by the anatomical and physiological characteristics of the organism.

2. Susceptibility of a periodic nature, which is associated with the activity of some particular life cycle function.

3. Susceptibility associated with meteorological conditions or agencies.

Electrical Injuries.

The increase in electric railroads, electric lighting systems and telephone lines, whose wires are usually located near the tree belts of our cities and towns, has made necessary a lamentable amount of disfiguring pruning. When strung too close to trees, wires also often cause serious injury by burning, sometimes mechanical injury is done, and lightning discharges will cause harm when guy wires are attached to trees.

Both the alternating and direct currents are used. They produce different physiological effects on plant life, the alternating current apparently being less injurious than the direct; and when either is used at a certain amperage it acts as a stimulus to the plant, and growth and development are accelerated.

There are minimum, optimum and maximum currents affecting plants. The minimum represents that strength of current which just perceptibly acts as a stimulus, and is very insignificant. The optimum is that producing the greatest stimulus — about .2 milliampere — and the maximum, that causing death. The maximum current necessary to cause death is very variable. The direct current has a less stimulating effect than the alternating, and on account of its electrolyzing effect is capable of causing more injury to vegetable life than the alternating current.

Most of the injury to trees from trolley or electric light currents is local, *i.e.*, the injury takes place at or near the point of contact of the wire with the tree. This injury is done in wet weather when the tree is covered with a film of water, which provides favorable conditions for leakage, the current traversing the film of water on the tree to the ground. The result of contact of a wire with a limb under these conditions is a grounding of the current and burning of the limb, due to "arcing." The vital layer and wood become injured at the point of contact, resulting in an ugly scar and sometimes the destruction of the limb or leader. In a large number of tests made by the aid of sensitive instruments with guy wire and other connections of wires to trees we have never found any leakage during fair weather or when the surface of the tree is dry. Since the amount of current that can be passed through a tree depends upon the resistance and electromotive force, we shall consider this resistance.

As might be expected, there is considerable difference in the electrical resistance of various trees as well as of the different tissues found in trees. The heartwood, sapwood, cambium, bark and sieve tubes possess quite different properties and functions, and their electrical resistance would naturally vary to a large extent. The living cells containing protoplasm, such as are found in the cambium, present the least resistance, as shown by various observations on lightning discharges. The minute burned channel caused by comparatively insignificant lightning discharges follows down the cambium, indicating that this is the line of least resistance. Moreover, by driving electrodes into a tree to different depths and measuring the resistance it can be shown that the least resistance occurs in the region of the cambium.

The electrical resistance may average throughout the year about 25,000 ohms in 10 feet of the trunk of a large maple tree, but in cold weather it often exceeds 100,000 ohms. The lowest resistance in all cases corresponds to periods of high temperatures, and the highest to periods of the lowest temperature. The difference shown by the various sides of the tree is also related to temperature. The resistance of the sapwood is very much greater, and probably that of the heartwood is even higher than that of the sapwood.

In determining the electrical resistance it is necessary to know the path or course of the current, and the only manner in which the resistance of different tissues can be determined accurately is by isolating the tissues. By girdling a tree and scraping the trunk down to the solid wood we can get the resistance of the wood. Mr. G. H. Chapman[1] found the resistance of a freshly cut rock maple stem, 1½ inches in diameter, to be 70,000 ohms with the bark on, but 150,000 ohms when the bark was removed. The electrodes were 1 foot apart. Next to the cambium the phloëm has the least resistance, followed by the sapwood. The outer bark appears to offer the most resistance, but when wet the resistance may be decreased, owing to the less resistant film of moisture on the bark. The resistance obtained from an elm tree in summer, with the electrodes 10 feet apart and in contact with the cambium, was 10,698 ohms, whereas when the electrodes were inserted into the middle of the cortex or phloëm we obtained 11,300 ohms' resistance. When driven one-quarter inch into the wood, and some of the exterior tissues surrounding the electrodes removed, the resistance was 98,700 ohms. The outer bark gave 198,800 ohms' resistance, but when the electrodes were inserted slightly deeper into the bark we obtained 109,900 ohms. It should be pointed out, however, that the data given here do not represent the actual resistances of the various tissues, but they indicate that there exist very material differences in the electrical resistance of the tissues in trees. The resistance obtained for the cambium, however, may be taken as fairly representative, as shown by the use of other methods, such as the employment of relatively high potentials and current measurements.

The resistance given by small tree trunks and woody stems, even for small distances, is quite large. About 4 feet of a young pear tree, including the root system, with a maximum diameter of stem equal to 1 inch, gave a resistance of about 300,000 ohms; and the resistance given by a tobacco plant, in which the distance between the electrodes was only 14 inches, was much higher (110,000 to 165,000 ohms) than that shown by trees at corresponding temperatures.

The water and various salts in the living plant undoubtedly play a rôle in resistance, and it might be expected that the various plastic substances would influence it also.

The cambium ring is very insignificant in size, and even on a large tree the total area is small. In all probability it is the protoplasm itself which

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[1] Mass. Agr. Exp. Sta. Rept. 24, Pt. I., 1912; also Bulletins 91 and 156.

offers the least resistance to the transmission of an electric current; and even if there were no continuity it would be necessary for the current to pass through a great many cell walls even for comparatively short distances on the trunk. In case the protoplasm was continuous or there existed continuity, the strands would be so very small that they would undoubtedly offer high resistance, due to their attenuation. Whatever conditions prevail, trees show relatively high electrical resistances, a feature which is no doubt of some biological importance. The high resistance of trees, moreover, is undoubtedly a protection in case of lightning strokes, since often the heat developed is enough to do only slight injury. On the other hand, if trees possessed tissue with relatively small electrical resistance, they would be more seriously affected by currents from high-tension wires. The electrical resistance of trees is so high that it is doubtful whether injury ever occurs to them from contact with low or even high-tension wires, except that produced by grounding when the bark is moist. Any escaping current from transmission lines that can be transmitted even through the least resistant tissue is likely to be insignificant.

FIG. 98. — Showing disfigurement of trees caused by high-tension alternating current wires.

Effects of Alternating Currents.

The alternating current systems employed for lighting purposes vary greatly in their potential. Cases of burning from alternating currents are more numerous than those from direct currents because trees are brought into more frequent contact with the wires, and, owing to the higher potential, more leakage is likely to occur. The high and low voltage lines may vary from 100 to 100,000 volts. The high-tension systems are invariably constructed across country, and are naturally not brought into very close proximity to shade trees. No injury to trees whatever occurs

from the low voltage (110-volt) lines, but the lines of higher potential found on streets constitute a source of danger to trees. The higher the electrical potential the more dangerous the wires become to trees, for, owing to the lessened effectiveness of the ordinary insulation, more leakage occurs and consequently greater opportunity for burning.

The effects of alternating currents on trees are local, producing injury only near the point of contact with the wire. Such contact results in death of that part of the tree, and if it is a leader or large limb it usually has to be sacrificed. In no case, to our knowledge, has an alternating current caused the death of a tree, although it may burn or disfigure the tree so badly that it amounts to practically the same thing. It is doubtful whether the current from a fairly high potential wire would kill a large tree under any circumstances. It is different in the case of small plants, as has been frequently demonstrated in the laboratory, although the current must produce heat enough to kill the protoplasm. The close relationship between the maximum temperature required to kill a plant and that induced by electrical current indicates that the collapse of the plant tissue in such cases is probably due to the heat rather than to any specific electrical shock. It is possible to pass the same current through larger plants where heat is not generated without causing any collapse of the tissue. The ordinary house circuit wires are perfectly harmless to trees, and it seems strange that a judge could render a verdict to the effect that an ordinary insulated 110-volt house circuit was responsible for the death of a tree whose terminal branches were located 3 feet from it. There is only one court record of which we know where such a judgment has been given.

Very high-tension line wires are not provided with insulation and are known to affect the atmosphere surrounding them to a considerable extent. Any increase in the electrical potential of the atmosphere if not too high would favorably affect vegetation in general.[1]

General Effects of Direct Currents.

Most of the direct currents affecting trees are those used for operating electric railroads. Trolley feeders may be at 500 to 550 volts. Ordinarily the burning from direct currents is similar to that produced by the alternating current in being largely local or confined mainly to the point of contact with the wires. The feed wires cause no burning except when the tree is moist, in which case grounding takes place.

The strength of current which will kill one plant will produce not the slightest effect on another; in other words, the maximum current for each individual varies materially. Small, tender plants possess a maximum much below that of woody plants. A young, succulent tomato

[1] There is evidently much difference in plants in this respect. A crop of radishes showed a gain of 57 per cent. when subjected to an average atmospheric potential of 167 volts, whereas an electrical potential equal to 500 or 1,000 volts is beyond the stimulation zone for some plants (16th Ann. Rept. Mass. Agr. Exp. Sta. (Hatch), 1904, p. 31).

plant, one-eighth inch in diameter and 5 inches high, was instantly killed when treated with a current of 20 milliamperes, and currents of 2 and 3 milliamperes of thirty to sixty seconds' duration accomplished the same result. In all the tomato plants, considerable heat was developed, and their death was caused by the generation of heat developed by the current. The electrodes in these tests were about one-half inch apart. If the electrodes had been farther apart, no perceptible effect would have been observed.

When trees with a more or less thick bark are drenched with rain the conditions are quite different. A large maple tree which was in circuit with a feed wire (500 volts) and rail of an electric road when dry gave a current equal to 70 milliamperes (one-fourteenth ampere) with the electrodes placed vertically 1 foot apart. These connections were left on the tree for several months. The observations were made on dry days and no appreciable amount of heat developed with this current. During periods of wet weather considerable heat always developed, especially at the positive electrode, but not enough to melt the soft solder which connected the wires with the electrodes.

Examination of the tree ten months later showed that a portion of the tissues near the electrodes had been killed. After removing the dead bark an oval space 6 by 11 inches was found to be dead about the positive electrode and a space about 1½ by 3 inches near the negative electrode. The burned area about the positive electrode was about 95 per cent. greater than that occurring about the negative electrode; in each case it extended about twice as far above and below the point of contact as out to the sides of the electrodes, thus showing a tendency of the current to spread laterally as well as vertically, but more largely vertically. The immediate area around the electrodes was more affected than that farther remote. There was an area of tissue about 5 inches long between the large and small oval burning that was uninjured, showing that burning was confined about the electrodes. The current traversing the film of water on the bark between the electrodes was not sufficient to destroy the tissues at that point.

If a milliammeter had been placed in the circuit when the tree was wet a greatly increased current would have been detected, since the current in this case traversed the less resistant film of moisture on the bark. But the electrical resistance of the vital layer under such conditions would remain practically the same as when the tree was dry, or it would show only such variation as might be induced by an increase in temperature. The burning and injury in this case resulted from the heating of the film of moisture, which became so intensely heated that the vital tissue was destroyed, especially near the point of insertion of the electrodes. The more the film became heated the greater was the lessening of the resistance and increase of the current.

Practically all of the burning of trees from either alternating or direct

currents occurs in this way, since the high electrical resistance characteristic of trees does not permit injurious currents to pass through their tissues.

Death of Trees from Direct Current.

Instances are known in which large trees have been killed by direct currents used in operating electric railroads. Attention was first called to these cases in Bulletin No. 91, issued by this station, and since the publication of this bulletin other cases have been observed. In all of these cases the escaping current had burned and girdled the trunks for a distance of from 5 to 10 feet from the base; the point of contact of the feed wire with the limb 18 or 20 feet above showing little or none of the characteristic local burning effects usually observed in ordinary cases of grounding. In fact, the difference between the burning from direct currents in these cases and that from ordinary cases of electrical injury may be seen at a glance. On electric railroad systems the so-called positive current generally traverses the overhead feed wire, where the injury (burning) takes place. It does not differ materially from that produced by low-tension alternating current wires. In all cases of death from direct-current electricity that have come to our notice, however, the rail was positive and the overhead wire was negative, constituting what is called a "reversed polarity." How common this practice is we cannot say, but apparently it has been employed intentionally at times to prevent electrolysis as well as unintentionally by various companies, and is responsible in a few instances for the death of shade trees near electric railroads. There is much greater opportunity for extensive burning in the case of reversed polarity than in the regular systems employed. The moisture conditions of the soil and bark are such as to reduce the resistance, and in consequence the film of water and the water-soaked bark

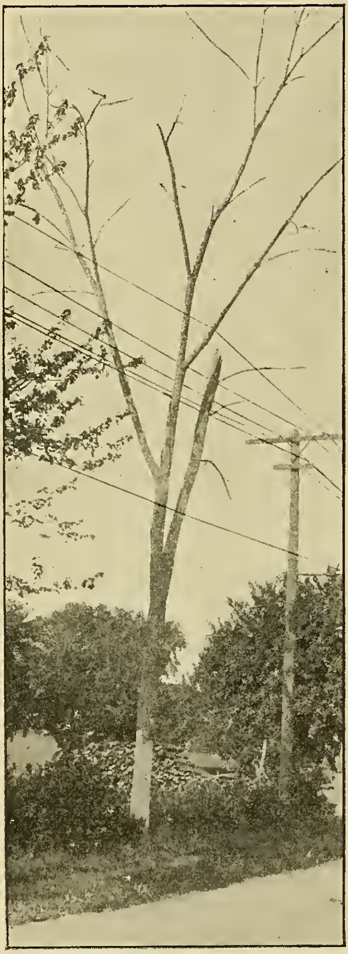

FIG. 99. — Showing elm tree killed by direct current (reversed polarity) from electric railway system. Note effects of burning at the base of the tree.

become intensely heated, destroying the living tissues and girdling the tree to a considerable distance. The part of the trunk towards the rail is almost invariably the most severely affected. With reversed polarity, as already pointed out, the injury is confined mainly to the base of the trunk, where the destruction of tissues causes great damage. Such damage does not occur when a positive overhead feed wire comes into contact with limbs. The entire area between the base of the tree and the overhead wire is not, as a rule, affected, although the extent of injury may vary somewhat. On the elm shown in Fig. 99 the burning was caused by a reversed system, and there was only slight injury at the point of contact with the overhead wire, while at the base about 6 or 7 feet of the tree were affected. This injury takes place when the soil and the bark of the tree are moist, and may occur during a single period of excessive moisture, or intermittently. In some instances trees show serious effects a short time after the current has been reversed, when the bark will become loose and later fall off. The writer has observed both elms and maples — some of them 2 feet or more in diameter — which have been killed in this way. In some cases the trees were not more than 3 feet from the rails, while in others the distance was considerably greater.

In one city, 51 trees were reported killed or so badly injured as to be of no value, 67 had large limbs removed, and many more were saved by removing limbs likely to come into contact with wires. Some of the injury took place on streets having trolley wires but no electric railways, and it is surmised that the ground connections were made through several pipe lines located near the trees, which led very close to the electric railway. According to Mr. G. A. Cromie,[1] who had these under observation, the injured trees were in some cases located from 200 to 1,000 feet from the track. The effects on the trees were noted shortly after the street railway had changed its system, *i.e.*, using the rail to carry the positive and the overhead wire the negative or return current. The trees in contact with the overhead wires became electrically charged, and when wet it was impossible for linemen to work on them. Under these conditions the insulation was much less efficient, and even wooden sleeves imbedded in coal tar and rubber proved of small use in preventing leakage. A large percentage showed a characteristic burning at the base, and the bark was burned off in some instances to quite an extent. One limb that had been in contact with the negative feed wire was found dead, but the tissue at the base of the trunk was normal. Dr. J. W. Toumey, director of the Yale Forestry School, who examined many of these trees, found a disintegration of the wire where it came into contact with the limbs, apparently due to electrolytic action, and chemical analysis showed the presence of copper and zinc in the tissues of the wood that had been in contact with the negative or overhead wire. Dr. Toumey believes that in such cases the disintegration of the copper wire and the absorption of the copper by the tissue were responsible for the death of the limbs. If

[1] G. A. Cromie, "Scientific American" supplement, No. 1985, p. 40, Jan. 17, 1914.

true, this entirely new state of affairs would indicate that the electrical injury from direct currents arises not only from heat but also from the electrical disintegration of metals, which may poison the tissues. These observations demonstrate that we have a variety of conditions to deal with in considering the effect of direct-current electricity on trees, and these phenomena may be summarized as follows: —

Burning and injury to plant tissue are much more prominent at points with a positive potential[1] *than at points with a negative potential.*

When the rail is at a positive potential and the overhead wire which touches some part of the tree is negative, and the bark and soil are saturated with moisture, a circuit is formed by means of this surface moisture.

The moisture conditions and the electrical resistance, etc., at the base of the tree are different from those above; therefore, a larger area of tissue is affected by the positively charged rail.

As the bark becomes heated through the film of water, the electrical resistance is reduced and the current increased to such an extent that the vital layer is destroyed.

The actual current passing through the inner tissues must necessarily be insignificant, and when there is a film of water on the bark, probably no current passes through the cambium; furthermore, the moist soil between the rail and the trunk of the tree becomes a better conductor for the current than the roots. The actual injury, therefore, is done by the current traversing the film of water rather than any of the inner tissues. The maximum heat and the areas most affected are near the base of the trunk.

In regard to the possibility of injury to large trees by direct currents passing directly through them, experiments show that what holds true for alternating currents is true also to a great extent of direct currents. However, it would require a voltage much higher than that furnished by most electrical railways at the present time.

It might be possible for direct currents to affect trees without causing any perceptible burning. If, for example, a tree were subjected to a sufficient strength of current, there might occur a disintegration of the cell contents, causing the tissues to become abnormal and finally to die, but the electrical resistance of trees is so great that a quite high potential would be necessary. If the potential of the electric railway systems were greatly increased it is possible that some injury might result to trees even under ordinary conditions.

Probably the amount of ground leakage occurring through imperfect rail connections would not cause any perceptible injury to trees; nor is there any direct evidence that lightning arresters when placed near trees cause any injury by discharges. However, the guy wires used by

[1] Positive electro-static charges have a more stimulating effect on plants than negative charges, and retardation of growth and injury to the cells are more pronounced. The phenomena associated with the positive and negative galvanotropic bendings of roots may be explained in this way (24th Ann. Rept. Mass. Agr. Exp. Sta., Pt. I., p. 144, 1912).

electric systems are a source of danger from lightning, and we have observed cases where large limbs have been destroyed and the trunks of the trees badly lacerated by electrical discharges from these wires.

On the whole, the cases of death to trees from electricity are by no means so numerous as is generally believed. Because a large number of

FIG. 100.—Showing electrolysis of gas pipes. (After A. A. Knudson, "Corrosion of Metals by Electrolysis.")

trees near electric roads, etc., often look sickly it must not be concluded that electricity is always the cause. In cities and towns, where most of these unhealthy specimens are found, there are innumerable destructive factors for trees to contend with. It is quite essential in diagnosis work, therefore, that all of these factors be taken into consideration before a definite opinion in regard to the cause of any abnormal condition is formed.

Electrolysis.

Direct current electricity is frequently responsible for electrolysis of gas and water mains, and lead coverings of underground telegraph circuits are often affected. The trouble is often so serious that the iron gas and water pipes become corroded and eaten with holes in a few weeks or months, causing leakage. When gas mains are affected by electrolysis, the gas escapes and permeates the soil, so that electricity sometimes becomes a primary and gas a secondary factor in the death of trees.

The phenomena associated with electrolysis are often complex and difficult to do away with entirely, according to expert electricians, but much of the trouble can be eliminated by proper bonding of the rails of electric roads and the grounding of different systems.

Electrolysis is more common in wet than in dry soils. Cases are on record where severe electrolysis has taken place 700 or more feet from the source of the leakage. It more often becomes troublesome in cities where numerous railways and public-service corporations of all kinds make use of the streets. We have observed cases where plants have been stimulated and their growth increased by escaping electricity in the soil.

Lightning.

The common effects of lightning strokes on trees are so well known that it is not necessary to dwell upon them here; but lightning does not always strike a tree in the same way, and the peculiar effects sometimes produced are often interesting. Very powerful discharges of lightning act somewhat

like an avalanche, causing a severe shattering of the tissue, while less powerful discharges may remove a strip of wood only a few inches wide and 1 or 2 inches thick. Lightning often takes a spiral course, following the grain of the wood, which is sometimes very irregular. Even when strips of wood 4 or 5 inches wide and 2 or 3 inches thick are removed, in which case the electrical energy is enormous, the path of the discharge is shown only by a dark-colored streak 2 or 3 millimeters wide.

FIG. 101. — Showing ridge on elm tree caused by feeble lightning discharge.

Sometimes trees are killed outright by lightning without being shattered or displaying any other of the common effects. In such cases the discharge is apparently dispersed so as to cause no visible mechanical injury to the tree, but the girdling of a large or small area of the living zone or cambium layer of the trunk would be sufficient to cause its death. This might follow as a result of an earth discharge either destroying the vital tissue directly or by a dissipation of heat over a surface film of moisture. In some instances the leaves wilt immediately and die, indicating injury from heat. However, in a very large number of instances neither death nor mechanical injury of any importance takes place. Hundreds of trees are annually struck by lightning that never show any effects except to those capable of interpreting the small narrow ridges which later make their appearance on the trunk. In such cases the lightning discharge follows the line of least resistance, — the cambium zone, — burning a small channel usually about 1 millimeter in diameter. The tissues surrounding the channel are apparently not injured, but the annular rings which are later formed outside the burned channel are much broader, resulting in the formation of a ridge on the bark.

Earth Discharges. — There are many cases of lightning that are apparently earth discharges. Their effect on the tree is quite characteristic and not at all similar to the ordinary forms of lightning strokes. Our attention was called several years ago to some shade trees to which lightning had apparently caused some injury. These trees were maples 5 to 18 inches in diameter, growing in soil composed mainly of gravel containing oxide of iron, and underneath this a stratum of quicksand. A considerable number of the trees showed the effects of repeated earth discharges, in some cases becoming so disfigured that they had to be replaced for the third time. These discharges occur during thunderstorms, and those who have observed them for many years relate that they give rise to a dull, characteristic report resembling that caused by throwing a wet

cloth on a hard surface. The whole tree is not affected as a rule, as the lightning stroke seldom follows up the main trunk, but discharges at the points of several branches. As a rule, however, one side of the trunk and one or more of the limbs on that side are affected and the symmetry of the tree destroyed. The first indication of the discharge is shown by the immediate wilting and subsequent death of the leaves of the affected limbs, which also die later. In the course of time cracks similar to those caused by frost, and later ridges due to healing, will be seen on the trunk, showing the path of the discharge, and occasionally, when the injury is considerable, the bark near the affected part of the tree falls off. The limbs, however, are not always killed, frequently splitting, and a cracking of the wood for some depth is now and then observed on the trunk and limbs along the path of discharge.

FIG. 102. — Maple showing effects of earth discharges (lightning), causing splitting of the trunk and death of limbs.

Whether the chemical composition of the soil has any particular bearing on earth discharges is not positively known. It is known, however, that there frequently exist great differences in the electrical potential between the earth and air during thunderstorms, and that the electrical conditions of the atmosphere and earth may change instantly from negative to positive. Some observations made in our laboratory with a Thomson self-recording quadrant electrometer show that the electrical potential of the atmosphere, at a distance of 30 feet from the ground, may vary, often in a brief period, from a few volts to 300 or more. It is also known that trees occasionally discharge sparks at their apices, showing that insignificant earth discharges occur through trees; and when the soil in which potted plants are growing is charged electrostatically, small sparks are thrown off from the leaves. Earth discharges through trees, whether strong or weak, appear to be similar in nature, and may be associated

with changes in the potential of the earth and atmosphere. The high electrical resistance shown by plants in general, as already stated, serves as a great protection against death from lightning and electric currents.

Susceptibility of Different Trees to Lightning Stroke. — There has always been much difference of opinion in regard to the susceptibility and non-susceptibility of various trees to lightning, and the data of the subject gathered from this and that source are altogether too meager to admit of reliable conclusions; but it is known that the location of the tree, nature of the soil, elevation, etc., are of great importance in determining susceptibility to lightning.

It has already been pointed out that electrical resistance is influenced by temperature, and the percentage of moisture in the tissues is also an important factor. During thundershowers, trees become more or less drenched with rain, and, according to Stahl,[1] the more thoroughly wet the tree is the less susceptible it becomes to lightning stroke. He bases his observations on the fact that smooth-bark trees, like the beech and others, which are considered more immune to lightning, become thoroughly wet during storms, while the oak and other rough-bark trees do not. Stahl's idea, therefore, is that smooth-bark trees possess a better water-conducting surface and have a tendency to equalize the electrical tension existing between the atmosphere and the ground, so that they are rendered less susceptible to lightning. His deductions were based upon experiments with electrical discharges made with the bark of different species of trees containing various percentages of moisture. He further observed that vertical limbs were more likely to become drenched than horizontal, and that the lenticels and stomata play a rôle in the equalization of the difference in electrical potential existing between the tissues and the atmosphere. There appears to be no difference in the electrical potential, at corresponding heights, under deciduous trees and in the open air when there is no foliage, while the electrical potential will average 40 per cent. less under the trees than in the open air when the foliage is developed.

The potential of the air is usually negative, although occasionally changing to positive. In the case of coniferous trees, however, like the Norway spruce,[2] we found that the potential under the foliage was invariably positive or similar to that of the earth, which may be explained on the theory that conifers are constantly discharging positive electricity to such an extent that the air surrounding them becomes charged similar to the earth. To what extent the film of water on the bark is capable of equalizing the difference in electrical potential in the air surrounding the trees, as well as in the ground and in the tissues themselves, has not been wholly determined, but we had difficulty in obtaining potential readings under the foliage of elms in wet weather in our experiments covering two summers. This may in part be explained by the improper installa-

[1] Stahl, E. Die Blitzgefährdung der verschiedenen Baumarten, Jena, G. Fisher, 1912.

[2] Mass. (Hatch) Agr. Exp. Sta. Rept., 1905, p. 14.

tion of our collector. It is not unlikely that the film of water on the bark of trees during such periods would have a tendency to affect materially the potential of the surrounding air, as Stahl has pointed out, and possibly to equalize the electrical tension. The subject should have further investigation, but we believe that it is possible to protect trees from injury by lightning, whether they be atmospheric or earth discharges.

Injuries to Trees from Arc Lamps.

Damage to trees from artificial light rarely occurs. We know of only one instance where any definite injury has occurred to trees from the use of the arc light. Mr. William G. Keith, gas and electric light commissioner of Chicago, Ill., has reported a case where the electric lights caused damage to adjacent trees located on certain streets in Chicago. The trees injured were in all cases young Carolina poplars. The particular lamps causing the trouble were known as the G. E. Company, type W, 10 ampere, 465 watt, 1,000 candle-power, series flame arc lamps, and were operated on the same circuits. These lamps were in operation nearly a year. Shortly after their installation damage occurred to the poplars adjacent to the lamps. The damage to the trees in all cases was confined to that side near the source of light, the trees being stripped of leaves and some of the branches apparently killed. The injury to the branches was such that they became infested with borers. As the injury to the trees seemed to be persistent where this type of lamp was employed and not noticeable where other types of lamps were used, — such as the direct-current open arc lamp and the 300-watt 600-candle-power gas-filled incandescent lamp, — the system was changed to the latter type, and the trees became normal, throwing out new twigs and leaves.

At first it was thought that the heat generated by the lamps was responsible for the damage to the trees, but the heat generated from the gas-filled lamps was equal to or greater than that from the other types; hence it appeared that the damage did not result from the heat. Finally it was demonstrated that the trouble was caused by the practice of emptying the contents of the globes, consisting of such products of combustion as fluorides and possibly other injurious salts which accumulate in them. The trees were located very close to the lamps and somewhat below them; hence in emptying the globes the poisonous products would fall on the foliage. As already stated, the injury in all cases occurred on that portion of the tree adjacent to the lamp, the other or remote portions being unaffected.

This is apparently the first authentic case at least of noticeable injury to street trees from electric lamps, and the theory of Commissioner Keith relative to the specific cause of the injury to the foliage — namely, it being due to the deposition of the products of combustion from the carbon on the foliage — appears to be a most rational one. It should be pointed out, however, that there are other ways in which injury of a similar nature might occur to trees from electric lights, and as innovations in

street lighting systems are frequent, attention should be given to this subject by those having the welfare of trees in their charge.

It would, of course, be possible for injury to be produced directly to the foliage of trees in close proximity to lamps resulting from the intense heat produced by the electric current setting free poisonous gases from the heated carbons used for lighting purposes, the carbons in such instances being composed of or containing chemical substances which when volatilized by intense heat and diffused in the atmosphere would be toxic to plants.

Moreover, it is possible for light itself to affect vegetation detrimentally. It is well known that artificial lights differ from sunlight very materially, and in proportion as they are characterized by rays of high refrangibility they produce abnormal conditions on vegetation. However, the injurious effects to plants resulting from various artificial lights can be and are eliminated to a large extent by the use of globes and glass screens. We have never observed, however, any detrimental effects upon shade trees from any lighting system which could be attributed to any peculiarity in the nature of the light itself.

The carbons in the older type of arc lamps which have been extensively used are supposed to be pure, while those used in the flame arc contain certain admixtures, such as fluorides. The older type of arc lamps provided with pure carbons were apparently harmless to street trees and to vegetation in general when the light was properly screened through glass, although more or less delicate, rapid-growing plants became abnormal when subject to the naked arc.

Apparently the flame arc lamps have not as yet been extensively employed on street circuits, and if the trouble to trees resulting from their use is caused by the deposition of the products of combustion of the carbons on the foliage, which appears to be the most rational explanation, it is not likely that any serious difficulty to street trees will follow their use if ordinary care is given to the handling of the residue which gathers in the globes.

Injury to Trees from Wires.

The constantly increasing use of electricity for various purposes makes necessary a more extensive use of wires, which has become a great menace to shade trees. The appearance of streets is injured by the increased number of poles and wires, and the legal restrictions as to the height, distance apart, etc., of the wires of the telephone, telegraph, trolley and electric light companies make the problem of maintaining shade trees on the same street with public-service corporations a serious one. Of all the troubles with which tree wardens have to contend, the wire problem is often regarded as the worst. Notwithstanding the strict laws which some States have adopted in regard to injuring shade trees, the agents of some public-service corporations often have little regard for trees or the laws respecting them. Where 40-foot poles must carry the wires of three or four public-

service corporations there can be little or no opportunity to preserve the natural symmetry of shade trees, especially when low branching maples and other trees are planted on the same side of the street with the wires. There is less interference from limbs with low than with high tension wires. Trees like the elm, whose branches form acute angles, offer less obstruction to wires than maples; but not all streets, of course, are planted with elms, which may be as well, considering their susceptibility to various pests and unfavorable climatic conditions.

The best solution of the wire problem lies in burying the wires. This has been done to quite an extent in large cities, especially in the business sections, the telephone corporations having adopted this system to a much greater extent than the electric light companies. It is an expensive system, however, and those who so strenuously advocate its adoption do not always consider that in the end it is the patrons who have to pay for it.

Fig. 103. — Showing the destructive effect on the growth of a maple tree of a mass of wires.

Another method of preventing wire injuries is the erection of high poles to bring the wires over the trees. This is sometimes done, especially where the trees are young or of a species that naturally grows low, when a very high pole would be sufficient to clear them for many years. The cable system may be used for telephone wires, and much injury to trees prevented. Large cables are rather expensive to install, but what is termed the "ring construction" system may be used to advantage in many instances, particularly in the suburbs. In this way it is possible to run a line through avenues of fine trees in the country districts without necessitating pruning or disfiguration.

Rights of way for poles on private property back of residences are sometimes secured, and by this means the poles and wires may be removed from the streets, much to the advantage of the trees. But such rights are often difficult to secure, and are not always satisfactory either to the public-service corporations or the owners of the property. The former naturally do not care much for these rights of way unless they are legal and permanent, and the owners in granting permanent rights run a risk of lowering the value of the property. Most of the very high-tension

transmission services, however, are at present on private property and seldom interfere with trees. High-tension lines are affected seriously merely by close proximity to trees; therefore, these rights of way have to include broad strips of land, which of course is expensive.

On general principles, it is not wise to allow wires to be attached to trees, although this is often done. Trolley and electric light wires are frequently guyed to trees, but they are a source of danger, since injury is likely to occur from the crossing of the wires, and lightning discharges occasionally pass from the wires to the tree, causing damage. It is, however, often better to allow this than to allow the erection of ugly poles; but proper insulation of the wires should be insisted on, although ordinary insulators have little effect on lightning discharges. The lagbolt system in common use for guying wires to trees is not the best method, for sooner or later the wire and bolt become imbedded in the tree and cause injury. Moreover, a direct metal connection with a tree is objectionable, as has in more than one instance been proved. The block system is better, although it may not in all cases be free from objections. (See Fig. 42.) In no case should a wire be allowed to pass tightly around a tree, as it will girdle it in time. When live wires come into contact with limbs, some type of insulator should be employed similar to that shown in (1), Fig. 105, of which there are various types, some being quite effective in preventing injury from low-voltage lines. The type shown in (2), Fig. 105, is cumbersome and unsightly, but is one of the most effective. The principle of the porcelain and dowel insulator is good, but it has a tendency to slide on the wires and to become displaced. If it were provided with larger dowels, and the danger of displacement on the wires done away with, it would prove much more satisfactory.

FIG. 104. — Showing maple tree injured by lightning discharge from trolley guy wire, causing death of limb and laceration of trunk.

Wires often accidentally come into contact with trees by the displacement of poles, particularly on curves where the strain is very great, but much of this injury may be prevented by imbedding the poles in Portland cement. It should be pointed out that the necessity for guying poles to trees may be obviated in this way.

Better methods of handling this vexatious question of wires and shade trees should be forthcoming in the future, and even at the present there must be a compromise between the tree warden or city forester and the companies as to the best method of wiring through tree belts and the amount of pruning allowed. Conditions at present favor the corporations,

as they are furnishing valuable and necessary facilities for business, and in towns they obtain their franchises and location of poles from the selectmen with little difficulty. The selectmen notify the abutters of any contemplated installations of poles and wires or of changes to occur in the systems, and the abutters are given a hearing. However, they usually wake up to their duty only after the installation of the lines, when the tree warden must assume all responsibility for injury to trees. He has to choose between two courses, — prevent the pruning or permit it. In either case the companies can erect the poles and install the wires, allowing the wires to burn their way through the trees, although this, of course,

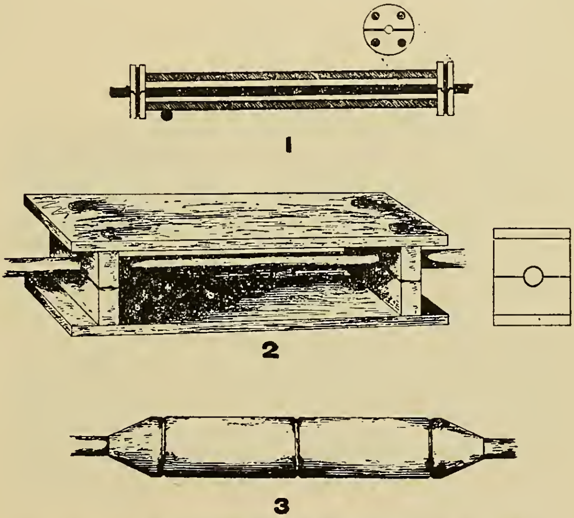

FIG. 105. — Showing different types of guards for electric wires: 1, porcelain dowel guard; 2, porcelain wood guard; 3, wooden sleeve.

often causes trouble to the corporation as well as to the abutter. In case of injury to trees the warden has access to the courts, but most companies are willing to put up with a few moderate fines for the sake of the right of way through a tree belt.

The Spraying of Shade Trees.

The great value and economic importance of spraying shade and fruit trees have resulted in placing on the market a large variety of fungicides and insecticides and types of machinery. Massachusetts has unfortunately been obliged to spend more money in spraying than any other State, and many towns and cities in the eastern part of the State, where the brown-tail and gypsy moths are so prevalent, appropriate thousands of dollars yearly for spraying.

Besides the larger spraying enterprises which are being carried on for the suppression of the gypsy and brown-tail moths, much private work is being done, and hundreds of tons of arsenate of lead are used annually in this work. While the above-named pests have not at present invaded the central and western parts of the State to any extent, other pests necessitate spraying our shade trees.

For years a great deal of attention has been given to the improvement of spraying machines, nozzles, etc. It has often been a question whether our towns or cities can afford to use the methods which are recommended and practiced by the best orchardists for shade trees. The aim of the orchardists is to cover every part of the tree which needs protection with a very fine mist spray. This method cannot be too closely followed by orchardists, since it is not necessarily expensive when only orchard trees and small fruits and crops, such as potatoes, are concerned. However

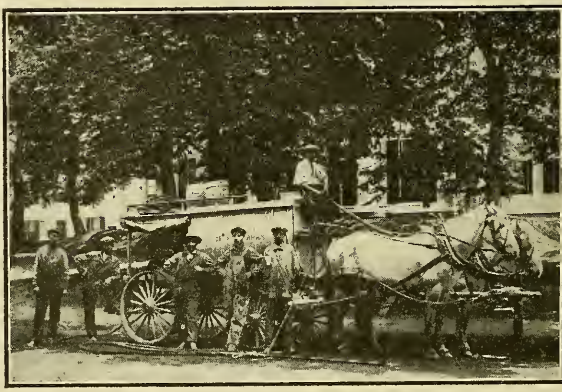

FIG. 106. — Large spraying equipment.

when we have to spray large elms, the question becomes an entirely different one.

A few years ago some large elms located in the public square in one of our cities were sprayed by the same methods used by the best orchardists, at an expense of something like $16 per tree. These trees, to be sure, were unusually large, but the cost was so great that in our opinion it set a limit to the amount of spraying which should be undertaken by such methods. Most of the former spraying of shade trees was done by this very expensive method at a cost of $1.50 upwards for trees 14 to 18 inches in diameter. In much of this early spraying the Vermorel, Ware or similar fine-spray nozzles on poles were used, and spraying had to be done at close range for the best results. The early gypsy moth work was done in this same way, any other method at that time being considered useless. This method entailed a great deal of climbing on the part of the sprayers, and was a slow and costly process. With the improvement of gasoline engines,

pumps, etc., together with the utilization of coarse nozzles, more efficient methods came into vogue. Some years ago the Gypsy Moth Commission abandoned these fine nozzles and close-range methods of spraying, and at the present time use is made only of wide aperture nozzles and solid streams, with large hose. Exceptionally high pressure is obtained from powerful machine sprayers. With the larger area which has to be treated at the present day the older method would prove prohibitory, not only on account of the expense, but also because of the time involved. Virtually all the spraying with these large modern machines is done from the ground, doing away with the necessity for ladders and for climbing trees; and by using one or more lengths of hose large areas may be treated from one spot. This method of spraying trees is very effective and very much cheaper, the average cost of spraying woodlands being something like $6 or less per acre. With this method the spraying mixture is delivered to the nozzle through a large strong hose 1 inch in diameter, under a pressure of 200 to 275 pounds, the high pressure breaking the spray up into a fine mist. The spray has considerable spread when broken up, which is a desirable feature in treating woodlands and country roadsides, but on this account it is more or less objectionable for use on residential streets in cities and towns, as it is likely to disfigure anything it touches. The high-pressure, solid-stream equipments are the cheapest, and are more practical for shade tree work than anything that has as yet been devised.

FIG. 107. — Spraying from the ground with solid stream and high pressure (Worthley nozzle).

What might be termed a compromise between the fine-nozzle system and the high-pressure, coarse-nozzle or solid-stream system employed in the gypsy moth work is often used in spraying shade trees at the present day. This consists in the use of the Bordeaux nozzle, which has an aperture of about three thirty-seconds of an inch. When used on a hand

pump with a pressure of from 50 to 70 pounds, or even more, it does not give, in our estimation, a satisfactory spray because it is not broken up sufficiently. When a small number of trees is to be sprayed and an expensive equipment cannot be afforded, small hand pumps will do the work, but when it becomes necessary to spray 500 or 1,000 trees in the course of a few weeks, power sprayers are necessary and more economical.

The Bordeaux nozzle has the advantage of being adjustable and can be used either as a mist nozzle or at more or less long distance. As a long-distance nozzle, however, under any pressure, it is unsatisfactory and much inferior to other long-distance sprays. Moreover, with the use of the Bordeaux nozzle it becomes necessary to use a ladder and to do some climbing. The aperture is so small that with any pressure the stream is limited in its height.

FIG. 108.—"M A. C." nozzle spray with high-pressure and atomizing point intercepting the stream.

The most important factors necessary for economical work in spraying shade trees on a large scale are machines powerful enough to maintain a constantly high pressure, an efficient nozzle, and competent men to do the work. By high pressure we mean a pressure of 200 to 250 pounds, preferably the latter. This should be maintained constantly, and the capacity should be sufficient to maintain this pressure in a 1-inch delivery hose, if necessary, provided with a nozzle with an aperture one-quarter inch or more in size. With the mist nozzles, or even with the Bordeaux nozzle, a pressure of over 150 pounds is useless and unnecessary. With this pressure, or even less, depending on the nature of the nozzle employed, the maximum results may be obtained. It is extremely important for the best work in spraying that there should be as little friction as possible. Therefore, care should be exercised to have no reducing valves or couplings anywhere on the line to reduce the volume, since it is essential to have an uninterrupted flow of the spraying mixture directly to the nozzle. In this respect the fixtures usually found on the market are poorly adapted to good work, and are often useless, with the

exception of those used by the State in spraying for the gypsy moth. These are excellent.

Too much attention cannot be given to the nozzle. It should be adapted to the work required of it, and a satisfactory or ideal nozzle is worth almost any price. It should be constructed on mechanical principles which will enable it to break up the spraying mixture into as fine a mist as possible, and to do this at a distance convenient for the economical spraying of trees. The ideal nozzle for spraying either from the ground or from a ladder should possess some carrying features, and still break up the spray finely. The nozzle should not be encumbered, any more than the hose, with worthless mechanical devices which produce friction without adding anything to its efficiency, and for this reason we believe that it is better to employ mechanical devices to break up the spray after it has left the nozzle rather than in the nozzle itself. This applies, of course, to that type of nozzle intended to be used with high pressure, either from the ground or from a ladder, since in this case it is necessary to have nozzles adapted to throw a certain distance in order to reach the foliage, and have it broken up into as fine a mist as possible. This does not apply to types of nozzles like the Vermorel and Friend, which are well adapted to the purposes for which they are intended.

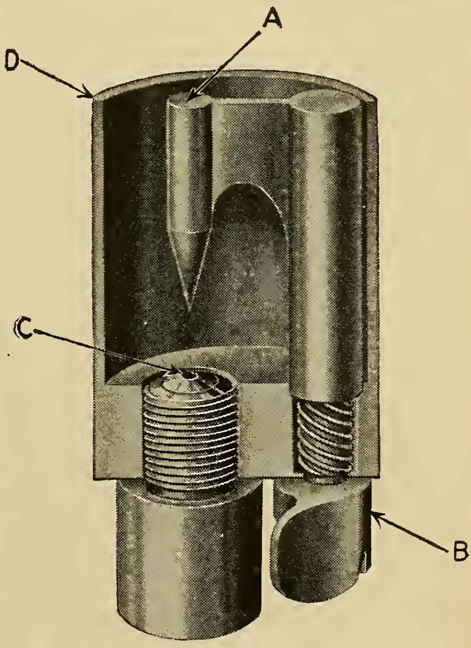

FIG. 109. — "M. A. C." nozzle. A, atomizing point or deflector; B, wing handle to adjust or swing point; C, nozzle proper; D, hollow case to protect A and C.

For high-pressure, solid-stream spraying in long-distance work, the Worthley tips are best. These tips range in size from one-eighth inch upwards, according to height of stream desired. They are constructed so as to break the stream into a mist at a certain height. With this type of nozzle the tops of trees can be sprayed most effectively, although the lower foliage does not receive so much of the spray. To overcome this difficulty the writer has devoted a great deal of time to experimenting with new types of nozzles, and from some forty or more designs two have been constructed which have given good results. One of these, known as

the "M. A. C. nozzle,"[1] has been patented and placed on the market. This nozzle is adapted for use with apertures ranging from one-eighth inch upwards, and is adjustable so that different types of sprays may be produced. It is designed for high-pressure work, and is more efficient at relatively close range than long distance; consequently, when used in connection with the Worthley tips an effective method of spraying results. With a three and one-half to six horse-power machine it can be used with one-eighth to three-sixteenths inch tips effectively, but in such cases a ladder must be employed with high trees.

The securing of competent men is also important in spraying. Any reliable man of common sense can learn to spray in a short time, and there should be little difficulty in securing such men if they are treated properly and well paid.

At the present time there are numerous types of spraying machines on the market ranging from two horse power on, and costing from $200 to $1,200. When it becomes necessary to spray a large number of trees in towns or cities, only the large size machine should be used, but the large machines are rather costly for small towns with a limited amount of work to be done.

In the case of towns having a limited amount of work to be done, it is better either to contract the work or secure a five or six horse-power machine. As a rule, contract spraying of shade trees, done with small hand pumps or with small machines, is quite unsatisfactory, the equipment not being adapted to the best work at the usual contract prices, especially when many large trees must be sprayed. The cost of spraying large trees with hand pumps or small machines with the Bordeaux nozzle should be at least $1.50 per tree, and few contractors take work at this price. When contracts are accepted at the price of 70 cents per tree the work must be slighted with the inferior equipment employed, and even then it is done at a loss. With the use of large machines and solid-stream sprays, city trees have been sprayed for about 20 cents each, and an average price in cities and towns would be from 20 to 39 cents. In one instance the average price for spraying about 900 elm trees, with an average diameter of 20 inches, during a period of six years was 57 cents per tree; a three and one-half horse-power engine and an "M. A. C. nozzle" were employed. Use was made of a ladder, but very little climbing was done, and the price represents the bare cost of material and labor. Deterioration of machinery, repairs, etc., are excluded. An outside contractor should of course receive considerably more for spraying to offset the extra items of expense, such as the cost of transportation, housing his men, etc.

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[1] This nozzle was devised by the writer, and the patents are held by the Massachusetts Agricultural Experiment Station. It is manufactured and sold by Brackett, Shaw & Lunt, 62 North Washington Street, Boston, Mass.

Valuation of Shade Trees.

The valuation of shade trees is a very important question, and opinions on the subject often differ greatly. There are several different ways of arriving at the value of a shade tree, but in all of them the many factors modifying the value of a tree must be taken into consideration.

Since a tree planted for its shade, ornamental purposes, etc., possesses a utilitarian or property value, its real worth is usually represented by the cost of duplication. The amount of reduction in value of property from the loss of a tree is simply equivalent to the value of the tree, which in turn is represented by the amount it would cost to duplicate it. There is a limit to the size of tree that can successfully be transplanted, but it is possible to duplicate an 18-inch tree, and the value of trees that are too large to transplant may be estimated proportionately.

The transplanting of large trees is thoroughly practicable when done by men who understand it. A tree 6 inches in diameter may be moved for from $6 to $20, and one 14 inches in diameter for from $30 to $80, depending upon the availability of transplanting apparatus and of suitable trees.

Another method of determining the value of a tree, mentioned briefly above and often used in court, is to determine the decrease in value of the real estate affected by the loss of the tree, and expert appraisers of property are usually called in when this method is used.[1]

This method has its limitations, for real estate men are not necessarily familiar with all the factors affecting the value of a tree, — diseases, expectation of life, etc., which must be taken into consideration; consequently, they often set the value too high or too low. Moreover, the price per foot of real estate has little or nothing to do with the real value of a tree, which may be worth as much on a piece of property valued at $2,000 as on one valued at $6,000. As a matter of fact, the trees located on real estate have very little effect on the price obtained for the property, this depending much more upon the ability of the salesman. Then, too, while trees, shrubbery and other ornamental planting undoubtedly add value to property, it is a question whether the buyer often very seriously considers this fact when it comes to actually paying over his money. A tree is likely to be destroyed at any time by wind storms, lightning, etc., in which case it is impossible to recover damages, and it therefore does not appeal to the average buyer as a substantial property asset. Trees may be insured, but the writer's experience is that comparatively few persons regard trees as of sufficient value to warrant much expenditure. This is substantiated by the fact that in only a few cases, where trees have been destroyed by public-service corporations, and damages paid for them, have we observed any attempt to replace the dead trees

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[1] Many trees attain to a diameter of at least 18 inches, and in many cases even more, in fifty years. Assuming that it costs $2 to plant a tree, and that it is worth $150 at this age and size when in good condition, the return on the original investment would be 9 per cent., compound interest.

with others of large size, and seldom even with small ones. Not infrequently the destruction of a tree is considered in the light of a blessing, although damages are always insisted on. It is almost invariably true that real estate owners who allow horses to disfigure their trees year after year, not showing enough interest to expend 75 cents or so for wire protection, usually insist on the heaviest damages when these same trees are destroyed by public-service corporations.

Another method of estimating the value of trees is by obtaining the cross-section area. Cross-section areas of trees are often obtained at a certain distance from the ground and the value computed at so much per square inch. The æsthetic features, location, species, imperfections, etc., are also taken into consideration in determining the value of the tree. This method may be used in deciding the value of trees too large to transplant, but even here some allowance should be made, since their utility, shade value, etc., do not increase proportionately with their increase in size.

There are many factors underlying the valuation of trees which should be, but seldom are, taken into consideration, and a short discussion of these follows: —

A tree may be valuable in more than one way. It may possess a *species* or *varietal* value, *i.e.*, it may be of a type possessing horticultural value for propagating purposes; it may possess *historic* value, such as the Washington elm and others; it may have merely a *sentimental* value, in being associated with some family event; or it may possess *æsthetic* value, from its landscape effect and intrinsic beauty; again, it may possess only a *timber* value, which in most cases is insignificant; and finally, it has a *utilitarian* or *property* value, which naturally includes many factors.

Other features which help to determine the value of a tree are as follows: —

Size. — Size is of importance in determining the value of a tree.

Form. — A tree may be of good size and of very poor shape. Unfortunately there are many trees which, on account of their poor shape, should never have been planted.

Vigor. — Shown by the rate of growth, size of leaves, color of foliage and condition of bark.

Susceptibility to Various Troubles, to Specific Diseases, etc. — These may follow as a result of the environment or may be peculiar to individuals.

Physical Condition. — Shown by freedom from cavities and wounds, caused by unscientific pruning and other mechanical agencies, — borers, various animals, etc.

Species. — The species is important also, not only from the standpoint of beauty but from its conformity to the environment, its longevity and susceptibility to disease. There are many species which were formerly of much greater value than they are to-day, owing to the increased number of troubles affecting them now, *e.g.*, the elm-leaf beetle, leopard moth, winter injury and drought.

Location. — If the importance of the location of a tree were better realized, much more accurate valuations would be given trees which have been destroyed. For instance, a tree located on a well-planted avenue is worth more than one growing on a poorly planted avenue.

A tree forming part of a symmetrical line of trees is, as a rule, of more value than one of an irregular group.

A tree planted too closely to others is of less value than one which has a chance to grow without restriction.

A tree located in a wide tree belt is worth more than one growing in a narrow tree belt.

A tree growing on a narrow avenue is of less value than one on a wide avenue, for in the latter case the water mains, sewers, etc., may be farther from the roots, which are less likely to become injured.

A tree growing inside the sidewalk is of more value than one growing on the edge of a road near the curbing, or in a ditch. Usually the farther from the roadbed the tree is located, at least in cities, the more valuable it is, for the roots are often amputated close to the trunk in street excavating, sidewalk and curbing construction, etc., and the tree is much more liable to injury from horses and trucks, runaways, etc.

A tree growing in a street where water mains, sewers, underground conduits and gas pipes are so numerous as to necessitate digging up the roadbed cannot have the value of one growing in an undisturbed roadbed.

A tree planted near manufacturing establishments or in other locations where it is subject to an atmosphere of smoke and various gases is also unfavorably located since its expectation of life is reduced.

A tree located where it is likely to become affected by sun scorch or drought is of less value than one growing under more normal conditions. Cultivated soil is better for a tree than a lawn, mowing or pavements, but next to cultivation the lawn conditions are most favorable. Abnormal chemical conditions of the soil and unsuitable soil texture affect growth and development. The location of a tree as regards distance and direction from a residence are important from the shade point of view.

Trees located close to oiled roadbeds are unfavorably situated, since the dust from oiled roads injures foliage. There is also a possibility of the roots themselves being affected by the oil.

On account of variation in their susceptibility to disease and to injury from climatic conditions, trees are often of more value in one location than another; for instance, those growing in country towns are usually under more wholesome conditions than those in cities. They may also be located in situations where certain pests thrive. While trees in cities are relatively short lived, they are considered of more value than town trees, because they serve a larger population.

The nature of the species and the conditions under which a tree is growing help to determine its expectation of life. An elm tree may live for two hundred to three hundred years in some localities, and in others sixty or seventy years is its limit, while the duration of life of other trees is even more restricted.

The extensive cutting of roots, made necessary by modern city street conditions, where business blocks with their deep foundations are often erected within a few feet of the highway trees, and where the placing of sidewalks, curbings and various other modern conveniences necessitate considerable excavating, renders even the most perfect specimen of tree almost worthless in a short time.

Court Decisions concerning Damages to Trees.

Of the many court decisions regarding the injury and death of trees, quite a few are valuable as precedents. It is too often the case that the official representatives of public-service corporations, which hold franchises granted by cities and towns, assume that the corporations have entire jurisdiction over everything interfering in any way with the operation of their systems. As regards this point may be quoted the decision of a justice of the Supreme Court, who stated that public-service corporations "have only such rights as others to the use of streets, and are subject therein at all times to reasonable regulation or even to termination at any time if the supreme authority acting in the public service shall so determine." He further maintains that "they have no rights of property in the streets, and their privileges are merely temporary ones, which may be recalled at any time and which carry with them no right of property whatever."

From a lack of understanding of or inability to conform to the law, and a disregard of the rights of the people, this often leads to friction between those having special care of trees and representatives of the corporations. The heads of corporations have always been better disposed toward public utilities than their representatives, and some of them have laid down stringent rules in regard to shade trees which their representatives are supposed to follow. Most States, however, recognize that trees located on public highways enhance the value of the abutter's property, and in case of the destruction of or injury to such trees, the abutter has the right to claim damages.

In a case decided by the Appellate Division, New York, an owner of land abutting on a city street, whose ownership did not extend to the middle of the street but "who had set out ornamental shade trees on the sidewalk in front of his premises at his own expense and with the sanction of the municipal authorities, is entitled to have such trees protected against negligent or willful destruction at the hands of third parties. He has a right in such trees in the nature of an equitable easement, and when one is girdled and destroyed by a horse, may recover from the owner of the horse the damages thus sustained."

In Minnesota an injunction was granted by the judge to restrain the defendant from cutting, mutilating or in any way damaging trees whose limbs were threatened by an old house that was being moved through the streets. Along the route which the building must take in the course of

moving were several shade trees which would have to be destroyed in order to move the building. The court maintained that "there can be no question of the right of plaintiff to the protection of the court to save these valuable trees from mutilation and possible destruction. The fact that these trees are in the street and not within the boundary line of plaintiff's premises does not alter in the least his right to have them protected, as they are his property. In the absence of proof to the contrary he is the owner of the land in front of his premises to the center of the street, subject only to an easement in the public to use it for the purposes of travel and the usual and ordinary incidents thereof. His rights of ownership yield only to the public welfare and convenience, and to the power of the municipal authorities to appropriately adapt the street and maintain it to meet the necessities of the travelling public."

From various court decisions it would appear that the value assigned to trees has sometimes been too high and often too low, and in the main, the extent of the damages resulting from the destruction of trees is based upon the deterioration occurring to the adjacent property. In general, it may be stated that a tree 18 or 20 inches in diameter, in good condition and in a desirable location, is worth $150, and a smaller one is of corresponding value. In private settlements, which are often made, for trees injured by public-service corporations, amounts ranging from $15 to $150 have been paid for trees of the above size, but in many cases from $40 to $100 is considered sufficient compensation for trees ranging from 10 to 18 inches in diameter, depending entirely, of course, upon the many factors that influence the value of a tree.

Several typical cases of court decisions concerning damages to trees follow: —

The jury of a circuit court in Missouri once awarded $200 against a telephone company for cutting out the top of a shade tree without consulting the owner. The tree in question was a 6-inch poplar which interfered with the telephone wires, and the workmen, without consulting the abutter, chopped out the top and center of the tree. The abutter sued for $300 and received $200.

A similar instance occurred in North Carolina, when an electric lighting company was sued for damages for cutting a tree on the edge of a sidewalk, even after being provided with the permission of the superintendent of streets, approved by the board of aldermen. The jury awarded the plaintiff a verdict of $499. Of course the case was appealed, but the judgment of the State Supreme Court was that while the city had the power under its charter to control streets and sidewalks and to remove obstructions when necessary, it did not, when it condemned land for highway purposes, acquire a title to it but merely a right of way over it, so that the plaintiff was still the owner of the tree.

In another case a resident of New York, owning residential property abutting on the city street, brought suit against a gas company for the destruction of trees by gas. The case involved the destruction of some

maple trees thirty-five years old, all in a thriving condition and furnishing good shade. Four of these trees were destroyed by the negligence of the gas company in permitting gas to escape from its pipes into the soil about the roots of the tree. Action was brought to recover the damages alleged to have been sustained by the plaintiff by reason of these facts, and the jury found a verdict in his favor for the sum of $150. Upon appeal to the Appellate Division, the judgment entered upon the verdict was unanimously confirmed. The court held, as a matter of law, that the plaintiff had a property right in these trees, although they were not planted upon lands to which he had a title.

The question of negligence in the destruction of shade trees is an important one, and opinions seem to differ as to what constitutes negligence. There are some cases in which negligence has not been established and decisions were rendered in favor of the defendants, although it should be pointed out that an appeal to the higher court often reversed such decisions. The case of Robbins *v.* the Hartford Gas Company, pertaining to the destruction by gas of shade trees located on the highway and on private property, resulted in a decision for the defendant, but on appeal to the higher courts the defendant made a satisfactory settlement with the plaintiff. In the case of Rooney *v.* the Hyde Park Gas Company, which involved a number of shade trees on the highway and on private property which were supposed to have been injured by gas, a decision was given in favor of the defendant. The gas leak as admitted by defendant occurred some distance away from the trees, and it was not established that they had been injured by gas, neither could negligence be established.

These cases concern action brought by property owners against public-service corporations for the destruction of trees, but in accordance with our Massachusetts statutes city foresters or tree wardens can bring action for injury or destruction to shade trees located on the public highway. For instance, the city forester of Springfield brought suit against the Springfield Gas Company for the destruction of sixty shade trees, and the judge rendered a verdict in favor of the defendant, since negligence was not established. The gas company, however, made no attempt to establish any case; moreover, they had previously settled with the owners of the adjacent property for many of the trees involved, thereby acknowledging in such settlement that the trees had been killed by gas.

In another case the town of Athol brought suit through the tree warden against the Athol Gas Company for killing public shade trees by gas. The decision given by the judge of the local court was in favor of the plaintiff. The gas company appealed, but again lost its case before a jury in the higher court. In the case of the Superintendent of Parks, Lowell, *v.* the Lowell Gas Company, in which some fifty trees were supposedly killed by gas, a fine of $900 was imposed on the company in the police court, the same being paid to the city treasurer. In addition to the fine, the gas company settled with many of the abutters.

A few years ago fifteen tupelo trees were cut on private land by an

electric railway company. The court awarded triple damages on the ground that the cutting was willful, and the company was fined $1,200.

A case is recorded of a superintendent of an electric light company being adjudged guilty in a Massachusetts court on a charge of injuring and destroying shade trees on the highway. The court imposed a fine of $25. In another case a lineman was fined $15 in the district court on complaint of a tree warden for climbing trees with spurs.

Innumerable other court cases could be cited similar to those already given illustrating the laws in regard to public shade trees. In some States, however, according to decisions of the courts, public shade trees may be destroyed from almost any cause without any compensation to the adjacent property owner. By far the larger number of cases of injury to and destruction of shade trees from various causes never reach the courts, and it is much better to arrive at some satisfactory settlement by arbitration than to resort to criminal proceedings. One Massachusetts city, however, has attempted to require a public-service corporation to give a bond for the payment of damages to trees, but this regulation was not adopted by the aldermen of the city.

There are only a few instances, to my knowledge, of the courts awarding damages for trees supposed to be killed by electricity. Most courts would undoubtedly allow damages for serious burnings brought about by wires, but there are only a small number of cases in which electricity has actually killed a tree and in these cases the death of the tree was due to a reversed polarity in the electric railways.[1]

Codified Shade Tree Laws of Massachusetts, 1915.

For several years prior to 1899 there was a provision in the Massachusetts statutes that towns might elect tree wardens. By the acts of that year it was provided that every town must elect a tree warden, and the duties and powers of the office were defined. The tree warden law of 1899, with certain amendments in details, remains in force to-day and regulates the care of shade trees in every town in the Commonwealth.

Chapter 145, General Acts of 1915.

Section 1. The powers and duties conferred and imposed upon tree wardens in towns by this act are hereby conferred and imposed upon the officials now or hereafter charged with the care of shade trees within the limits of the highway in cities, by the charters of the said cities, by other legislative enactments, or by the ordinances of the said cities, and upon such officials as the city governments shall designate to have charge of said shade trees where it is within their power to transfer such duties, by ordinance or otherwise.

Section 2. The tree warden may appoint and remove deputy tree wardens. He and they shall receive such compensation as the town determines or, in default thereof, as the selectmen allow. He shall have the care and control of all public shade trees, shrubs and growths in the town, except those within the limits of a

[1] Electrical Injuries to Trees, Mass. Agr. Exp. Sta. Bul. 156, 1914.

state highway, and except those in public parks or open places under the jurisdiction of the park commissioners, and of those, if so requested in writing by the park commissioners, and shall enforce all the provisions of law for the preservation of such trees, shrubs and growths. He shall expend all money appropriated for the setting out and maintenance of such trees, shrubs and growths, but no trees shall be planted within the limits of a public way without the approval of the tree warden; and in towns until a location therefor has been obtained from the selectmen or road commissioners, where authority has been vested in said commissioners. Regulations, other than those made by the terms of this act, for the care and preservation of public shade trees made by him, and in towns approved by the selectmen, and posted in two or more public places, imposing fines and forfeitures of not more than twenty dollars in any one case, shall have the force and effect of town by-laws. All trees within or on the limits of a public way shall be public shade trees; and when it appears in any proceeding where the ownership of or rights in the tree are material to the issue, that, from length of time or otherwise, the boundaries of the highway cannot be made certain by the records or by monuments, and that for that reason it is doubtful whether the tree be within or without the limits of the highway, or is public or private property, it shall be taken to be within the limits of the highway and to be public property until the contrary is shown.

SECTION 3. Except as provided by section five, public shade trees shall not be cut, trimmed or removed, in whole or in part, by any person other than the tree warden or his deputy, whether such person is or is not the owner of the fee in the land on which such tree is situated, except upon a permit in writing from said tree warden, nor shall they be cut down or removed by the tree warden or his deputy or other person without a public hearing at a suitable time and place, after notice thereof posted in two or more public places in the town or city and upon the tree at least seven days before such hearing, and after authority granted by the tree warden therefor: *provided, however*, that if the tree warden shall refuse to cut or remove or issue a permit to any such owner to cut or remove any such tree or other growth, the damages, if any, sustained by him shall be determined in towns by the selectmen and in cities by the officer or officers in charge of the public shade trees and shall be paid by the town or city. Any person aggrieved by the action of the selectmen or said officer or officers in charge of the public shade trees as to the trimming, cutting, removal or retention of any such tree, or as to the amount awarded to him for the same may have the damages, if any, which he has sustained, determined by the superior court for the county in which the said tree is or was situated, upon a petition filed for the purpose, in the same manner as for the taking of land for ways; and his damages, so determined, shall be paid by the town or city,

SECTION 4. Tree wardens shall not cut down or remove or grant a permit for the cutting down or removal of a public shade tree if, at or before a public hearing as provided in the preceding section, objection in writing is made by one or more persons, unless such cutting or removal or permit to cut or remove is approved by the selectmen or by the mayor.

SECTION 5. Tree wardens and their deputies, but no other person, may, without a hearing, trim, cut down or remove trees, under one and one half inches in diameter one foot from the ground, and bushes, standing in highways; and, if ordered by the mayor and aldermen, selectmen, road commissioners or highway surveyor, shall trim or cut down trees and bushes, if the same shall be deemed to obstruct, endanger, hinder, or incommode persons travelling thereon. Nothing contained in this act shall prevent the trimming, cutting or removal of any tree which endangers persons travelling on a highway, nor the removal of any tree, if so ordered by the proper officials, for the purpose of widening the highway, and nothing herein contained shall interfere with gypsy and brown tail moth suppression, as carried on under the direction of the state forester and the United States department of agriculture, except the cutting and removal of trees, shrubs and growths that are one and one half inches or more in diameter one foot from the ground.

SECTION 6. Whoever violates any of the provisions of the preceding sections of this act shall forfeit not more than five hundred dollars to the use of the town or city.

SECTION 7. Towns and cities may appropriate money to be expended by the tree warden in planting shade trees in the public ways, or, if he deems it expedient, upon adjoining land, at a distance not exceeding twenty feet from said public ways for the purpose of improving, protecting, shading or ornamenting the same: *provided, however*, that the written consent of the owner of such adjoining land shall first be obtained.

SECTION 8. The Massachusetts highway commission shall have the care and control of all trees, shrubs and growths within the limits of state highways, and may trim, cut or remove such trees, shrubs and growths, or license the trimming, cutting or removal thereof. No such tree, shrub or other growth shall be trimmed, cut or removed by any person other than an agent or employee of the commission, whether such person is or is not the owner of the fee in the land on which such tree, shrub or growth is situated, except upon a permit in writing from said commission: *provided, however*, that if the commission shall refuse to issue a permit to any such owner to cut or remove any such tree, shrub, or other growth, the damages, if any, sustained by him shall be determined by said commission and paid by the commonwealth. Any person aggrieved by the action of the commission as to the trimming, cutting, removal or retention of any such tree, shrub or other growth, or as to the amount awarded to him for the same by the commission, may have the damages, if any, which he has sustained, determined by the superior court for the county in which the said tree, shrub or other growth is or was situated, upon a petition filed for the purpose, in the same manner as for the taking of land for highways, and his damages, so determined, shall be paid by the commonwealth.

SECTION 9. Whoever affixes to a tree in a public way or place a play bill, picture, announcement, notice, sign, advertisement or other thing, whether in writing or otherwise, or cuts, paints or marks such tree, except for the purpose of protecting it or the public and under a written permit from the officer having the charge of such trees in a city or from the tree warden in a town, or from the Massachusetts highway commission in the case of a state highway, shall be punished by a fine of not more than fifty dollars for each offence. Tree wardens shall enforce the provisions of this section: *provided, however*, that in case of the failure of a tree warden to act in the case of a state highway within thirty days after the receipt by him of a complaint in writing from the Massachusetts highway commission, said commission may proceed to enforce the provisions of this section.

SECTION 10. Whoever without authority trims, cuts down or removes a tree, shrub or growth, within the limits of a state highway or maliciously injures, defaces or destroys any such tree, shrub or growth shall be punished by imprisonment for not more than six months or by a fine of not more than five hundred dollars, to the use of the commonwealth.

SECTION 11. Whoever, wilfully, maliciously, or wantonly cuts, destroys or injures a tree, shrub or growth, which is not his own, standing for any useful purpose, shall be punished by imprisonment for not more than six months or by a fine of not more than five hundred dollars.

SECTION 12. Whoever wantonly injures, defaces, or destroys a shrub, plant or tree, or fixture of ornament or utility, in a public way or place or in any inclosure, or negligently or wilfully suffers an animal driven by or for him or belonging to him to injure, deface or destroy, such shrub, plant, tree or fixture, or whoever by any other means negligently or wilfully injures, defaces, or destroys such shrub, plant or tree, or fixture, shall forfeit not more than five hundred dollars, one half to the use of the complainant and one half to the use of the city or town in which the act was committed; and shall in addition thereto be liable to said city or town or other person interested in said tree for all damages caused by such act.

SECTION 13. Section fifteen of chapter twenty-five of the Revised Laws, in so far as it relates to trees; section ten of chapter fifty-one of the Revised Laws, in so far as it gives authority over trees and bushes; sections one hundred and one, one hundred and two and one hundred and four of chapter two hundred and eight of the Revised Laws, as amended by sections thirty-one and thirty-two of chapter five hundred and forty-four of the acts of the year nineteen hundred and two; section twelve of chapter fifty-three of the Revised Laws, as amended by section two of chapter two hundred and ninety-six of the acts of the year nineteen hundred and eight and by chapter three hundred and twenty-one of the acts of the year nineteen hundred and ten; section thirteen of chapter fifty-three of the Revised Laws, as amended by section three of chapter two hundred and ninety-six of the acts of the year nineteen hundred and eight; section sixteen of chapter twenty-five of the Revised Laws; section one of chapter three hundred and sixty-three of the acts of the year nineteen hundred and ten; and chapter two hundred and seventy-nine of the acts of the year nineteen hundred and five, as amended by chapter two hundred and ninety-seven of the acts of the year nineteen hundred and eight, are hereby repealed.

SECTION 14. The provisions of this act, so far as they are the same as those of existing statutes, shall be construed as continuations thereof and not as new enactments.

SECTION 15. This act shall take effect upon its passage. [*Approved April 7 1915.*

R. L., CHAPTER 208, SECTION 115.

LAW REGARDING THE POSTING OF NOTICES, ETC., WITHIN THE LIMITS OF THE HIGHWAY.

Whoever paints, or puts upon, or in any manner affixes to, any fence, structure, pole, rock or other object which is the property of another, whether within or without the limits of the highway, any words, device, trade mark, advertisement or notice which is not required by law to be posted thereon, without first obtaining the written consent of the owner or tenant of such property, shall, upon complaint of such owner, or of his tenant, or of any municipal or public officer, be punished by a fine of not more than ten dollars. Any word, device, trade mark, advertisement or notice which has been painted, put up or affixed within the limits of a highway in violation of the provisions of this section shall be considered a public nuisance, and may be forthwith removed or obliterated and abated by any person.

BULLETIN No. 171.

DEPARTMENT OF CHEMISTRY.

A CHEMICAL STUDY OF THE ASPARAGUS PLANT.

BY F. W. MORSE.[1]

Introduction.

The chemical composition of the asparagus plant (*asparagus officinalis*) has been under investigation in this laboratory for several years. The studies were begun in connection with a series of fertilizer experiments which have been conducted at Concord, Mass., where asparagus culture is an important industry.

The chemical composition of the asparagus plant has heretofore received comparatively little attention. Rousseaux and Brioux,[2] in a study of commercial asparagus culture in France, include numerous determinations of the inorganic constituents. Tanret[3] has investigated the soluble carbohydrates, or sugars. Wichers and Tollens[4] have reported the composition of the roots and crowns at different seasons. A few scattered analyses of the edible stalks have been found in different publications.[5]

Our studies have included several stages in the development of the asparagus plant, and also the effects produced by different methods of fertilization.

Crowns and Roots.

The first lot of material collected for the investigation consisted of crowns and roots taken from the experiment field at Concord early in November, 1908. One-year-old plants had been set in this field in the spring of 1907; therefore the roots when sampled were two and one-half years from the seed.

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[1] The author's indebtedness to Director Wm. P. Brooks and Dr. J. B. Lindsey for important suggestions regarding the work is gratefully acknowledged.

[2] Rousseaux and Brioux: Ann. Sciences Agron., 3d Series, I. (1906), pp. 188–326.

[3] Tanret: Bull. Soc. Chim. (4) 5, p. 889 (1909).

[4] Wichers and Tollens: Journ. fur Landwirthsch., 1910, p. 113.

[5] N. Y. Agr. Expt. Sta. Bull. 265; Office Expt. Sta. Bull. 28, p. 37.

The material was collected at this time for the purpose of determining the influences of the different fertilizers on the proportion of the reserve plant foods stored in the roots. The first crop of stalks would be cut from the plots in the following spring, and it was desirable to ascertain if any relationship could be demonstrated between the reserve food stored in the roots and the amount of growth made in the spring.

At the time the roots were dug the tops of the plants had been killed by frost and the stems were breaking down. It was consequently assumed that the roots had stored all the reserves of plant food which the stalks would have for their growth in the following spring.

Since these samples were primarily for studying the effects of fertilizers, each plot was represented by four plants which were selected by the size and number of their stalks, on the assumption that a plant with an average amount of tops would possess an average lot of roots.

The crown and attached roots of each plant were dug with spade and trowel by means of which the longest roots were followed to their tips. The word "roots" is used here to designate the rod-like storage roots of the plant, and not the fibrous feeding roots which were rubbed off during the washing process.

The roots in this lot were selected and the digging supervised by Mr. E. F. Gaskill, assistant agriculturist. The subsequent preparation of the samples for chemical analysis was supervised by Mr. P. H. Smith, in charge of the feed and dairy section of this department. The writer was assigned to this investigation in January, 1910, and the work has since been wholly in his charge.

A second lot of roots was collected on Nov. 4, 1910, by the writer and Mr. Gaskill after the plants had been set in the field three and one-half years. Two crops of stalks had been cut for market during their life, — a short crop in 1909 and a full crop in 1910. Plants were selected as before by the size and number of the matured stalks, which were in the same condition of decay as in 1908.

The roots had now ramified to such an extent that those of adjacent plants were more or less intermingled, making it impracticable to follow all roots of selected plants to their tips. Therefore a circle with a radius extending halfway to the adjacent plants in the row was cut with a spade around the chosen plant, after which the crown and attached storage roots were removed from the soil. It was noted that most of the roots ended in the characteristic pointed tips without cut ends, and were therefore fully representative of the plant.

The roots were shaken free of soil, put in sacks and shipped to Amherst. Two days elapsed between the removal of the roots from the soil and their reception at the laboratory. Upon their arrival they were placed in a cool cellar used for vegetable storage.

Each crown was next separated into small sections in order to remove adhering soil, and the parts, together with the attached roots, were scrubbed with a stiff brush, after which they were rinsed in clean water.

The material was next spread on a large sheet of paper in a cool place until the surface was free of adhering moisture. Each individual crown and its accompanying roots were then weighed and the weight noted down for the subsequent calculations as the fresh or green weight from the field.

The first stage of preparation of the material for analysis was to pass a sample, consisting of one crown and its corresponding roots, through a hand-lever feed-cutter, by which they were cut to lengths of about 1 inch (2.5 centimeters). The sample was then placed in a large steam-heated drying oven, where the temperature was about 55° C., and dried until sufficiently brittle to be easily pulverized.

In pulverizing asparagus roots for analysis certain properties of their constituents made serious trouble. During the preparation of the first lot of roots in 1908 Mr. Smith found the dried material to be so hygroscopic that in damp weather it would quickly become sticky and gum the mill. The friction of grinding was also apt to produce sufficient heat to make the material sticky and hopelessly cement the grinding plates together. By using a ball mill in dry weather he finally succeeded in reducing the samples to powder.

The writer's procedure with the samples of 1910 was as follows: immediately after removing the dried sample from the oven the material was allowed to cool a short time in the air and then weighed. Directly after weighing the sample was passed through a large drug mill, by which it was reduced to a mixture of coarse fiber and fine powder, the fiber coming from the outer walls of the roots and the powder from the interior and the crown. The mixture was subsampled by two successive quarterings.

The subsample was next sifted by means of a millimeter sieve, which separated nearly all of the fine powder from the fibrous shreds. By this step the hygroscopic, gummy constituent was largely eliminated from subsequent milling and the coarse fiber was pulverized about as readily as wheat bran, until it also passed through the millimeter sieve. The entire material of the subsample was thoroughly mixed and preserved in a tightly corked bottle for analysis. Care was taken to conduct all the operations in a dry atmosphere.

On June 23, 1911, at the end of the cutting season, a third lot of samples was taken for the purpose of determining the amount of exhaustion which the reserve material in the roots had undergone in producing the crop recently harvested. This lot of roots was collected under the supervision of Mr. C. W. Prescott, who was in charge of the Concord experiment field. There was practically no top growth by which to judge the size of a crown, and the roots were therefore necessarily chosen more at random than in the previous cases. On arrival of the roots at the laboratory they were treated in the manner described for the samples of 1910.

The average fresh weight of forty-four roots gathered from eleven different plots was found to be for each of two years, as follows: 1908,

1,092 grams; 1910, 2,440 grams. In two years the crowns and roots had more than doubled in size and weight.

The average weight of sixteen roots from four plots in each of three years is as follows: 1908, 1,120 grams; 1910, 2,393 grams; 1911, 2,401 grams.

The roots obtained in 1911 actually averaged slightly heavier than those selected the fall before. This may in part be due to the more random choice of samples in the summer before there was sufficient top growth to guide the selection, but is more probably the result of a higher water content in the growing season, as will be seen in the table of composition.

It has already been mentioned that the first object in collecting the different series of roots was to ascertain the effects of different fertilizers on their composition, but it is deemed best to present first the average composition of the roots at different stages of development, and follow with the composition of other parts of the plant before taking up the specific influences of methods of fertilization.

In furtherance of the primary object of the investigation, forty-four crowns, representing eleven different plots, were collected in the fall of 1908; seventy-six from nineteen plots in the fall of 1910; and sixteen from four plots in the summer of 1911.

A complete analysis was not made of every sample. Nitrogen was determined in every individual sample of each year. Total sugar was determined in about two-thirds of the samples obtained in 1908, and in every sample of the lots of 1910 and 1911. Ash and ash constituents were determined in every sample of the lot of 1908, but only in composite samples representing the individual plots in the series of 1910 and 1911. Dry matter was determined in every sample of 1910 and 1911, but was not calculated in the samples of 1908 because the weights after the first drying were omitted. The other constituents — fiber, pentosans and fat — were determined in selected samples in each series, chosen from some with average percentages of nitrogen or sugars, and others with maximum or minimum proportions.

In compiling averages for each year from the numerous analyses of individual samples above mentioned there were included only those figures obtained on samples from plots receiving complete fertilizers in some form, and results from plots receiving no nitrogen, no potash or no phosphoric acid were omitted.

Composition of Asparagus Roots.

	November, 1908.	November, 1910.	June, 1911.
Dry matter,	–	21.10	18.62
Ash in dry matter,	6.56	6.89	8.93
Protein,	12.25	12.44	12.75
Fiber,	15.39	19.77	23.66
Fat,	.98	1.77	1.63
Nitrogen-free extract,	64.82	59.13	53.03
Sugar in dry matter,	39.98	31.52	23.20
Pentosans,	8.91	10.96	11.66
Lignin, etc.,	15.93	16.65	18.17
Total nitrogen,	1.96	1.99	2.04
Protein nitrogen,	1.19	1.05	1.30
Amino nitrogen,	.77	.94	.74

NOTE. — The analytical methods employed throughout this work were those of the Association of Official Agricultural Chemists in all essentials.

The comparison shown by the table is of great interest. As the roots increased in size from 1908 to 1910 there was not a marked change in all constituents. The slight increase in ash may have been due to increased absorption and storage, and in part caused by the impossibility of thoroughly removing the adhering soil in washing the roots. The nitrogen percentage was practically unchanged, showing that the roots demanded and received that element as fast as new growth developed. There was a change in the relative proportions of the non-nitrogenous materials. In the soluble and active form the sugar was much less in the older roots, while the different inactive forms had all increased (fiber, pentosans, lignin and fat). There was a small change in the porportion of protein and amino nitrogen, which may have been a seasonal difference.

The sixteen random roots selected in 1911 from four plots, as already shown, weighed a trifle more than the roots gathered the fall before from the same plots. The analyses showed, however, a lower percentage of dry matter and actually lower weight on that basis. There was a pronounced exhaustion of sugars in the spring growth, but none of the other constituents; instead, the other constituents were increased in proportion to the loss of sugars. Nitrogen, which would be also indispensable to new growth, was not consumed at the rate of sugar, but was transferred to the growing stalks at a rate which left its proportion in the parent crown almost unchanged. Total ash was not reduced but largely increased as the organic matter was consumed. These points will be considered again in connection with the development of the tops of the plant.

Asparagus Stalks.

The marketable portion of the asparagus plant consists of the young stalks cut from the crowns during the spring and early summer. Their constituents must be mainly derived from the reserve materials stored the previous summer in the roots, and the total quantity removed in a season represents the drain which the roots must be prepared to meet.

Our first samples of young stalks were obtained from the experiment field at Concord in 1910, but it was clearly evident that during the two or more days which elapsed between cutting in the field and delivery at the laboratory there were destructive changes taking place in the soluble carbohydrates or sugar of the cells. Consequently in the spring of 1911 a series of samples of young stalks was gathered from the experiment field at Amherst, which had been fertilized in a similar manner to the field at Concord.

Samples of stalks were cut from four different plots in the home field on four different dates, beginning May 17 and ending June 14. The stalks were cut as close to the crown as possible, and averaged about 10 inches (25 centimeters) in length. The common practice of asparagus growers in Massachusetts is to grow the crop so that most of the stalk is above ground, and when trimmed to the standard length of 8 inches (20 centimeters) it is nearly all green. The material used in our investigation represented the crop as cut from the crowns before it is bunched and trimmed. Each plot sample consisted of all the stalks which were tall enough to be marketable on the day of cutting.

Immediately after the samples were cut they were taken to the laboratory, where the stalks were wiped with a dry cloth to free them from adhering soil, after which the samples were weighed. The stalks were then broken into short pieces and spread on a tray which was placed in the steam-heated drying oven at a temperature of 55° to 60° C.

In preparing asparagus stalks for analysis it was found necessary to avoid a large amount of cut or broken surface, since the contents of the ruptured cells changed rapidly during the early drying stage by a process of fermentation with a loss of soluble sugar. Too high a temperature would soften the tender tips or buds of the stalks and cause them to stick to the tray. Pieces of stalks about 3 inches (7.5 centimeters) in length withered quickly in a temperature of 55° to 60° C., and at the end of twenty-four hours the largest butts were split in half, longitudinally, to promote further rapid drying. Samples dried in this manner were subsequently found to have retained their sugar unchanged, or at least under such conditions there was obtained the maximum proportion of sugar.

Composite samples from all plots represented each date of cutting, in order to determine the rate of change in their composition as the season advanced. The following table shows this composition: —

Composition of Asparagus Stalks in Spring.

[Parts in 100.]

	May 17.	June 1.	June 8.	June 14.
Water,	92.31	92.35	92.30	92.24
Dry matter,	7.69	7.65	7.70	7.76

Composition of Dry Matter.

	May 17.	June 1.	June 8.	June 14.
Ash,	8.77	9.07	8.47	8.47
Protein,	33.25	31.19	29.75	28.87
Fiber,	18.90	17.15	18.82	17.92
Fat,	2.84	3.03	3.20	3.22
Nitrogen-free extract,	36.24	39.56	39.76	41.52
Total sugars,	9.91	15.47	15.64	19.87
Reducing sugars,	7.75	11.66	12.04	13.22
Pentosans,	14.23	12.80	13.39	13.21
Lignin, etc.,	12.10	11.29	10.73	8.44
Total nitrogen,	5.32	4.99	4.76	4.62
Protein nitrogen,	3.07	3.06	2.99	3.15
Amino nitrogen,	2.25	1.93	1.77	1.47

Two notable sets of changes occurred in the composition of the series of samples.

Sugars increased remarkably in the successive periods, while protein and lignin decreased. Dry matter was practically constant. In 1914 two other lots of stalks were analyzed primarily for another purpose, but protein, sugar and dry matter behaved in a manner similar to that of the earlier samples.

	May 25.	June 2.
Dry matter,	7.64	7.68
Total sugar in dry matter,	20.55	27.39
Reducing sugar in dry matter,	14.25	20.29
Protein,	29.30	28.45

It seems probable that this change in amount of sugar is due to photosynthesis, since so much of the stalk is above ground and supplied with chlorophyl. Growth is somewhat slower as the season advances after

the first rapid development in warm days of May, giving more time for the photosynthesis to go on. It does not seem reasonable that the drain on the roots should be inversely proportional to the reserves in them. The decrease in nitrogenous matter does follow the exhaustion of the roots. The change in protein is a steady decrease in the amino nitrogen, while the true protein remains practically constant. This points also to more self-support and slower growth.

Asparagus Tops.

The development of reserve food material by the asparagus plant has been studied by the analysis of samples of fully grown tops in midsummer and ripened tops in late fall. Two series of samples were collected from the fertilizer plots at Concord, — one in October, 1911, and the other in August, 1912. These were taken for the purpose of ascertaining whether the reserves were affected in any manner by the different fertilizers employed. Upon analyzing them it was noted that soluble carbohydrates were very low, and the possible destruction by respiration during the time required to transport the samples from Concord to Amherst led to taking parallel samples at Amherst for the study of their composition at the two stages of growth.

To avoid serious injury to the crowns, representative samples for each stage of growth were obtained by pulling only one stalk from a crown. Seven average plants yielded in this manner an abundance of material for a sample, and two parallel samples were thus selected on the different dates.

To ascertain how fast translocation of reserves was taking place the tops were divided into two portions. Each top was trimmed to a single stalk and thus was formed two samples, — stalks and branches.

The lot of tops was weighed as soon as removed from the field, then divided into stalks and branches, each portion being weighed. Each separate sample was now spread in the sun in the glass house for twenty-four hours, and then run through a fodder cutter. The samples were next dried in the large steam-heated oven until brittle enough to be ground, when they were cooled in the air, weighed and pulverized for subsequent analysis.

The summer stage of growth was after blossoming was about over, and the stalks chosen bore no berries. This stage was considered by analogy with other crops to be the stage of maximum growth of tops, and that the reserve material in the tissues would be at the maximum.

The ripened stage was when the stalks had turned yellow and the needles were falling from some of the stalks. The tops selected were those which shed but few when handled.

Composition of Asparagus Tops.

Seven stalks, Aug. 16, 1912, weighed, green, 1,791 grams. Branches were 60 per cent. and stems were 40 per cent. of total weight.

Seven stalks, Oct. 23, 1912, weighed, green, 1,859 grams. Branches were 64 per cent. and stems were 36 per cent. of total weight.

	Summer Tops.		Fall Tops.	
	Stems.	Branches.	Stems.	Branches.
Dry matter,	23.76	28.43	24.18	32.15
Ash in dry matter,	7.39	7.31	9.36	8.51
Protein,	7.94	17.31	4.47	11.00
Fiber,	44.83	29.76	45.11	32.02
Fat,	1.38	4.89	1.35	5.23
Nitrogen-free extract,	38.46	40.73	39.71	43.24
Total sugar,	14.28	8.68	9.34	7.09
Pentosans,	15.90	14.15	15.86	14.41
Lignin,	8.28	17.90	14.51	21.74
Reducing sugar,	12.50	2.99	8.76	3.99
Protein nitrogen,	1.03	2.42	.74	1.56
Amino nitrogen,	.24	.35	–	.20

Protein and sugar both disappear with ripening in about the same proportion, and appear to be the only groups of constituents subjected to translocation. The translocation of sugars as they are formed is indicated by the higher percentages in the stalks than in the branches, both in midsummer and in autumn.

In November (the 4th), 1914, six tops were gathered which were golden yellow in color but bare of needles. Dry matter, sugar and protein were determined with the following results: —

	Per Cent.
Dry matter,	49.45
Sugar,	4.08
Protein,	4.70

It is probable that neither sugar nor protein is completely transferred to the root, because until killed by frost the living cells must still contain active protoplasm and its supply of food.

The more extensive series of samples collected at Concord completely corroborate these changes in kind, but respiration undoubtedly affected the sugars. The average composition of the lots is given in the following table: —

Composition of Dry Matter.

	Summer Tops, 11 Samples.	Fall Tops, 7 Samples.
Ash,	9.34	8.65
Protein,	17.47	7.94
Fiber,	33.04	43.75
Fat,	2.71	3.49
Nitrogen-free extract,	37.44	36.17
Sugars,	5.29	-
Pentosans,	15.58	20.90
Lignin, etc.,	16.57	15.27
Total nitrogen,	2.79	1.27
Protein nitrogen,	1.63	1.27
Amino nitrogen,	1.16	-

PROGRESSIVE CHANGES IN COMPOSITION OF THE ASPARAGUS PLANT.

The following table has been arranged in order to compare the composition of the successive stages of growth which have been studied: —

	Autumn Roots, 1910.	Summer Roots, 1911.	Young Stalks.	Summer Tops.	Autumn Tops.
Water,	78.90	81.38	92.30	73.44	70.73
Dry matter,	21.10	18.62	7.70	26.56	29.27
Composition of Dry Matter.					
Ash,	6.89	8.93	8.69	7.34	8.81
Protein,	12.44	12.75	30.77	13.56	8.65
Fiber,	19.77	23.66	18.20	35.79	36.73
Fat,	1.77	1.63	3.07	3.48	3.83
Total sugars,	31.52	23.20	15.22	10.92	7.90
Reducing sugars,	-	-	11.17	6.79	5.70
Pentosans,	10.96	11.66	13.41	14.85	14.92
Lignin by difference,	16.65	18.17	10.64	14.06	19.16
Total nitrogen,	1.99	2.04	4.92	2.17	1.38
Protein nitrogen,	1.05	1.30	3.07	1.86	1.26
Amino nitrogen,	.93	.74	1.85	.31	.12

The relation of water to intensity of growth is clearly shown by the changes in the proportion of water at the different stages of development. The summer roots procured in the midst of the growing season contained more water than the dormant roots obtained the fall before. The tops when just at their full height in midsummer were more watery than those that were ripening in the following October. But the most striking proportion of water was found in the tender, succulent stalks of spring and early summer at the period when growth is so rapid that it can be readily measured from hour to hour.

The active part performed by sugar is indicated by the difference in the percentages of this substance found in the various stages of the development of the plant. The large proportion of reducing sugar in the stalks and tops at the successive stages sampled, and its absence from the different series of roots, is in accord with distinction between active and reserve forms of sugars. The sugar in the roots at the seasons chosen for their study was wholly a reserve substance, and being readily soluble in water passed unchanged toward the actively growing stalks.

The insoluble non-nitrogenous substances which form the bulk of the plant at each stage of growth undergo the usual inverse changes in proportion which accompany the increase and decrease of more active constituents.

Amino compounds are an important part of the reserve nitrogenous material in the fall roots, as their nitrogen forms almost one-half of the total percentage of the element at that stage. This is a larger proportion than at any other stage, and points to its probable value for rapid transfer to the young stalks in the spring.

The Inorganic Constituents of the Asparagus Plant.

For comparing the progressive changes in the mineral constituents of the different stages of the asparagus plant we have used the averages of all results from the plots receiving complete fertilizers.

At first sight the average composition of the three series of roots appears to be practically alike, but a closer scanning reveals consistent variations in some of the constituents from year to year. Calcium, sulfur and sodium steadily increased in percentages from stage to stage in the roots, and also between the summer and fall stages of the tops. On the other hand, potassium, magnesium and phosphorus varied between narrow limits in the different stages of root development, and were noticeably diminished in the final ripening stage of the tops. These three elements are evidently translocated from the old tops to other parts of the plant, while the three first mentioned go in only one direction and accumulate as those parts of the plants grow older.

Sulfur is considerably in excess of phosphorus, which is unusual in our common garden crops. While no provision was made for this in planning the fertilizer, there was apparently enough of the element present in the stable manure or superphosphate used.

The translocation of potash, magnesia and phosphoric acid back to the roots is indicated but not proven, since there are the blossoms and berries to be considered as a possible destination in their transfer. These two sets of organs were not collected, however, as it was nearly impossible to get anything approaching accurate amounts of them from a series of stalks, because the red asparagus beetle destroys them in preference to other parts of the plant.

Inorganic Constituents of the Asparagus Plant at its Different Stages (Percentages in Dry Matter).

	Autumn Roots, 1908.	Autumn Roots, 1910.	Summer Roots, 1911.	Young Stalks.	Summer Tops.	Autumn Tops.
Calcium oxide,	.316	.360	.436	.387	.994	1.635
Magnesium oxide,	.151	.192	.184	.346	.243	.190
Potassium oxide,	2.445	2.465	2.374	5.270	3.436	2.189
Sodium oxide,	.245	.368	.366	.330	.203	.431
Phosphoric acid,	.507	.464	.442	.538	.472	.169
Sulfuric acid,	.509	.627	.730	.833	.472	.532

Effect of Fertilizers on the Composition of the Asparagus Plant.

The material for the study of the effects of fertilizers on the composition of the different parts of the asparagus plant was chiefly obtained from the experiment field [1] at Concord, but some was taken from the plots at the experiment station in Amherst.

The soil of the experiment field is typical of the soils chosen in Massachusetts for asparagus culture, *i.e.*, a coarse, sandy loam. Samples of the soil from four sections of the field were analyzed by the conventional method, and the results are given in the following table: —

Soil Analyses.

	Volatile Matter.	Insoluble Matter.	Calcium Oxide.	Magnesium Oxide.	Potassium Oxide.	Phosphoric Acid.	Sulfuric Acid.	Total Nitrogen.	Humus.
Surface.									
Southeast,	4.26	89.43	.20	.07	.09	.25	.04	0.13	1.97
Southwest,	4.55	89.86	.22	.02	.09	.21	.04	0.14	1.94
Northeast,	4.14	90.49	.23	.02	.10	.27	.04	0.13	1.85
Northwest,	4.25	90.27	.22	.01	.07	.20	.05	0.13	1.78
Subsoil.									
Southeast,	2.61	91.01	.08	.01	.09	.03	–	–	–
Southwest,	2.11	93.32	.13	.03	.09	.04	–	–	–
Northeast,	2.17	93.30	.06	.02	.10	.05	–	–	–
Northwest,	2.71	92.84	.04	.01	.08	.08	–	–	–
Second Foot.									
Southeast,	1.88	92.29	.07	.02	.10	.03	–	–	–
Southwest,	1.17	94.03	.09	.01	.12	.06	–	–	–
Northeast,	.79	95.62	.06	.04	.09	.05	–	–	–
Northwest,	.80	96.03	.06	.02	.09	.04	–	–	–

[1] See annual reports for 1908 and following years for description of fertilizer experiments.

These analyses were made by Messrs. E. B. Holland and R. D. Maclaurin before the field was planted in 1907. It will be readily seen that the samples show a striking uniformity in composition.

The manner of fertilizing the experiment plots has been described in a previous paper,[1] but for the sake of clearness the scheme is here briefly outlined.

Plot.	Application.	Pounds per Acre, Nitrate of Soda.	Pounds per Acre, Acid Phosphate.	Pounds per Acre, Muriate of Potash.
1	No nitrates,	–	200.1	260.0
31	Low nitrate, in spring,	311.2	200.1	260.0
32	Low nitrate, in summer,	311.2	200.1	260.0
33	Low nitrate, half in spring, half in summer,	311.2	200.1	260.0
34	Medium nitrate, in spring,	466.6	200.1	260.0
35	Medium nitrate, in summer,	466.6	200.1	260.0
36	Medium nitrate, half in spring, half in summer,	466.6	200.1	260.0
37	High nitrate, in spring,	622.4	200.1	260.0
38	High nitrate, in summer,	622.4	200.1	260.0
39	High nitrate, half in spring, half in summer,	622.4	200.1	260.0
40	No nitrate,	–	200.1	260.0
5	No phosphate,	466.6	–	260.0
6	Low phosphate,	466.6	133.4	260.0
7	Medium phosphate,	466.6	200.1	260.0
8	High phosphate,	466.6	266.8	260.0
9	No potash,	466.6	200.1	–
10	Low potash,	466.6	200.1	173.4
11	Medium potash,	466.6	200.1	260.0
12	High potash,	466.6	200.1	346.8

Effect of Fertilizers on Asparagus Roots.

The roots of 1908 represented only the plots that had received different applications of nitrate of soda; the samples of 1910 included these plots and the plots to which different quantities of acid phosphate and muriate of potash were applied. The weights of the roots are given by individuals and by plots in the following table: —

[1] Ann. Rept., Mass. Agr. Expt. Sta. 25, p. 156.

Weights of Asparagus Roots when taken from the Field (Grams).

Series of 1908.

Plot.	Root I.	Root II.	Root III.	Root IV.	Plot Average.
1,	566	1,177	792	974	877
31,	1,268	883	1,177	770	1,024
32,	997	861	952	884	923
33,	1,020	635	1,020	907	895
34,	1,338	1,701	975	1,043	1,264
35,	1,360	1,134	680	1,927	1,275
36,	1,338	1,020	1,179	1,315	1,213
37,	1,542	1,224	1,179	1,406	1,338
38,	1,837	1,519	1,020	839	1,304
39,	544	1,020	476	884	731
40,	907	1,474	1,701	635	1,179

Series of 1910.

Plot.	Root A.	Root B.	Root C.	Root D.	Plot Average.
1,	2,262	2,070	1,816	1,951	2,025
5,	1,896	1,633	1,561	2,043	1,783
6,	2,960	3,012	2,573	2,868	2,853
7,	2,885	2,791	2,869	2,393	2,734
8,	2,182	2,265	1,833	2,703	2,246
9,	1,509	1,282	2,110	1,792	1,673
10,	2,827	3,015	1,993	1,745	2,395
11,	3,410	2,402	2,661	3,097	2,892
12,	1,986	2,967	2,691	3,194	2,709
31,	3,317	1,486	1,985	3,393	2,545
32,	1,918	2,570	1,526	2,000	2,003
33,	2,655	2,440	1,861	3,195	2,538
34,	3,540	2,119	2,677	2,595	2,733
35,	1,957	1,700	2,470	3,029	2,289
36,	2,043	4,432	2,282	3,598	3,089
37,	2,677	3,227	2,448	3,062	2,853
38,	2,807	2,313	2,446	1,676	2,310
39,	1,989	1,927	2,065	2,927	2,227
40,	3,042	1,717	2,197	1,967	2,231

There cannot be said to have been any specific effect of the nitrate of soda on the size of roots in 1908. The weights of the four roots from any given plot varied more widely among themselves than the plot averages differed from one another.

There were some consistent variations in the weights of the roots dug in 1910. The roots from plots 5 and 9, lacking phosphoric acid and potash, respectively, were consistently lower in weight than the roots from any other plot. The results of the absence of a nitrogen application to plots 1 and 40 were not positive because there were numerous roots from other plots receiving nitrogen that were no heavier individually, and the average weights for plots 32 and 39 were as small.

Comparing plot averages in the series 31 to 39, the average weights of roots from plots 32, 35 and 38 were consistently lower than those of the roots from plots 31, 34 and 37, which indicated the probable effect of a spring top-dressing to be an increase in the size of the roots. Nevertheless, the variations in weights of individual roots from any one of the plots is wide, and renders the conclusion from averages doubtful.

The effect of fertilizers on the inorganic constituents was thoroughly studied by the complete ash analysis of each root dug in 1908, and similar work on composite samples from the different plots in 1910. All the ash analyses were made in the fertilizer section by Messrs. H. D. Haskins and L. S. Walker, to whom the writer is indebted for the data which appear in the tables.

Inorganic Composition of Asparagus Roots (Percentages in Dry Matter).

Roots of 1908.

Plot.	Averages by Plots.						
	Total Ash.	Calcium Oxide.	Magnesium Oxide.	Potassium Oxide.	Sodium Oxide.	Phosphoric Acid.	Sulfuric Acid.
1,	5.53	.30	.14	2.12	.07	.44	.35
31,	5.96	.26	.14	2.03	.24	.48	.39
32,	6.63	.29	.13	2.62	.18	.56	.38
33,	6.61	.29	.15	2.33	.18	.52	.45
34,	7.12	.35	.16	2.62	.31	.55	.49
35,	6.46	.31	.16	2.51	.22	.48	.51
36,	6.49	.29	.14	2.23	.27	.49	.48
37,	6.41	.32	.14	2.15	.25	.52	.52
38,	7.01	.40	.16	2.44	.21	.56	.56
39,	6.41	.30	.14	2.47	.32	.47	.47
40,	5.89	.29	.12	2.45	.07	.50	.45

Inorganic Composition of Asparagus Roots — Concluded.

Roots of 1910.

Plot.	Averages by Plots.						
	Total Ash.	Calcium Oxide.	Magnesium Oxide.	Potassium Oxide.	Sodium Oxide.	Phosphoric Acid.	Sulfuric Acid.
5,	6.81	.41	.18	2.36	.43	.47	.69
6,	7.09	.32	.16	2.66	.35	.46	.63
7,	7.54	.37	.21	2.73	.38	.46	.69
8,	7.34	.38	.19	2.55	.33	.49	.63
9,	5.94	.38	.19	1.44	.55	.44	.66
10,	6.17	.33	.18	2.10	.48	.42	.57
11,	6.18	.34	.19	2.21	.33	.46	.62
12,	7.10	.40	.20	2.53	.33	.48	.62

There was no specific effect of fertilizers observable in the ash constituents, except on plots 1 and 40 in the 1908 series, and plot 9 of the 1910 series. Soda was notably lower in the roots from the first-named plots, which had received no nitrate of soda, than in all other roots which had been dressed with that salt. The composite sample representing the last-named plot, which had received no potash salt, showed a much lower percentage of potassium oxide than any other sample of that year, and a small increase in sodium oxide.

The most notable fact observable in the ash constituents was the high percentage of sulfuric acid relatively to phosphoric acid. Withholding acid phosphate from plot 5 had no apparent effect in reducing either the phosphoric acid or the sulfuric acid in the sample from that area.

Total Nitrogen in the Dry Matter of Asparagus Roots.

Roots of 1908.

Plot.	Root I.	Root II.	Root III.	Root IV.	Plot Average.
1,	1.21	1.29	1.36	1.30	1.29
31,	1.69	1.36	1.30	1.89	1.56
32,	1.96	1.93	1.65	1.54	1.77
33,	1.70	1.36	1.51	2.31	1.72
34,	2.43	2.01	2.18	2.12	2.18
35,	2.23	2.14	2.51	2.01	2.22
36,	1.56	1.92	2.05	2.16	1.92
37,	1.92	1.99	2.10	1.87	1.97
38,	2.20	2.51	2.51	2.19	2.35
39,	1.84	1.92	2.08	2.10	1.98
40,	1.50	1.22	1.21	1.20	1.28

Total Nitrogen in the Dry Matter of Asparagus Roots — Concluded.

Roots of 1910.

Plot.	Root A.	Root B.	Root C.	Root D.	Plot Average.
1,	1.67	1.77	2.05	1.69	1.79
5,	2.14	2.20	2.46	2.28	2.27
6,	2.12	2.25	1.93	1.97	2.07
7,	2.13	2.24	2.45	1.92	2.18
8,	1.94	2.08	1.99	2.15	2.04
9,	1.82	1.81	2.33	2.44	2.10
10,	2.40	1.98	1.61	2.18	2.04
11,	2.26	1.90	1.86	2.23	2.06
12,	1.91	2.27	2.25	1.87	2.07
31,	1.72	1.43	1.76	1.77	1.67
32,	1.81	1.96	2.02	2.23	2.00
33,	1.73	2.02	1.59	2.01	1.84
34,	2.02	2.02	1.89	1.99	1.98
35,	2.01	1.95	1.87	2.23	2.01
36,	2.07	1.79	1.91	2.00	1.94
37,	1.90	2.24	1.91	1.79	1.96
38,	2.32	2.07	2.60	1.89	2.22
39,	1.82	2.44	1.66	2.02	1.98
40,	1.59	1.30	1.06	1.22	1.29

Total nitrogen was determined in every root sample. The results individually and by plot averages are consistent. The absence of nitrogen in the top-dressing results in a low percentage of nitrogen in the roots from plots 1 and 40. The minimum and medium applications of nitrate show results on the percentages of nitrogen in the roots following the same order in relative quantities. The maximum application of nitrate of soda produced no result in excess of the medium application.

The application of the nitrate in midsummer was accompanied by a positively higher percentage of nitrogen in the roots from those plots, viz., plots 32, 35 and 38.

There was no apparent effect of fertilizers on the organic constituents of the roots, except that due to the influence on the nitrogenous group. High protein was accompanied by a lessened sugar percentage, but low sugar percentages also frequently occurred with low protein, in which condition there was a high fiber content. Consequently sugar and fiber fluctuated widely in samples from the same plot on account of some condition that was independent of fertilizers.

This wide fluctuation was most extreme in plot 9 of the 1910 series,

and if the average for the plot were compared with those of the others in the series it would appear clearly to be an illustration of the effect of potassium on the formation of sugar; but there were two roots with normal percentages of sugar from the plot, while there were roots in plots 5, 7 and 8 which were abnormally low where muriate of potash was regularly applied in the normal quantity. It is the writer's opinion that these variations in sugars on this group of plots may have been due to an attack of rust in the summer of 1910, although special pains were taken to avoid plants which had thus suffered, when the sample roots were selected.

Furthermore, it is believed that there were two positively different types of plants in these series in mode of growth, viz., one type with numerous slender, long roots, and the other with fewer but thicker, fleshier roots. This fact was not noted soon enough to correlate the observations with the analytical data, but it is reasonable to assume that the slender roots would have more epidermis in proportion to volume than the fleshy roots, which renders it probable that the former would have more fiber and less sugar than the latter.

Organic Composition of Roots.

Roots of 1908.

Plot and Root.	Moisture.	Protein.	Fiber.	Sugars.	Pentosans.	Fat.
1 (I.), ...	2.09	7.37	14.91	47.12	-	-
1 (II.), ...	2.14	7.90	12.70	49.72	7.17	.80
1 (III.), ...	2.77	8.34	18.20	40.24	8.82	1.20
1 (IV.), ...	2.33	7.93	16.30	44.44	-	-
31 (I.), ...	2.00	10.36	15.07	42.28	-	-
31 (II.), ...	2.70	8.34	14.78	43.96	8.91	1.04
31 (III.), ...	2.16	7.93	14.92	44.36	9.00	.98
31 (IV.), ...	3.08	11.58	14.92	40.00	-	-
32 (I.), ...	2.37	12.07	15.10	-	-	-
32 (II.), ...	2.59	11.82	14.86	-	-	-
32 (III.), ...	2.18	10.10	13.98	42.00	8.25	1.05
32 (IV.), ...	2.59	9.45	18.22	38.04	9.18	1.05
34 (I.), ...	4.06	14.65	14.15	35.24	8.17	.56
34 (II.), ...	4.00	12.08	14.66	37.12	8.51	.68
34 (III.), ...	3.64	13.19	14.19	-	-	-
34 (IV.), ...	3.42	12.81	14.62	-	-	-
35 (I.), ...	2.06	13.69	17.23	36.00	8.46	1.09
35 (II.), ...	3.19	13.00	12.98	40.60	7.88	1.07
35 (III.), ...	4.31	15.12	15.22	-	-	-
35 (IV.), ...	3.34	12.13	15.26	-	-	-

Organic Composition of Roots — Continued.

Roots of 1908 — Concluded.

Plot and Root.	Moisture.	Protein.	Fiber.	Sugars.	Pentosans.	Fat.
37 (I.),	2.34	11.68	13.50	43.20	7.88	.81
37 (II.),	3.16	12.07	14.86	–	–	–
37 (III.),	3.01	12.69	13.52	–	–	–
37 (IV.),	2.91	11.32	18.31	33.16	9.65	1.20
38 (I.),	3.35	13.31	15.54	–	–	–
38 (II.),	3.02	15.27	17.40	24.28	10.24	1.13
38 (III.),	3.60	15.19	13.18	–	–	–
38 (IV.),	2.92	13.33	12.31	44.52	7.94	.84
40 (I.),	2.50	9.14	13.69	–	–	–
40 (II.),	2.71	7.31	13.91	–	–	–
40 (III.),	2.07	7.37	14.54	44.32	8.27	1.31
40 (IV.),	2.13	7.30	11.97	48.72	8.48	.87

Roots of 1910.

Plot and Root.	Moisture.	Protein.	Fiber.	Sugars.	Pentosans.	Fat.
1 (A),	3.56	10.07	–	34.80	–	–
1 (B),	3.07	10.77	19.33	28.10	9.44	1.27
1 (C),	4.49	12.19	–	24.04	–	–
1 (D),	4.90	9.94	–	27.48	–	–
5 (A),	5.50	12.63	–	19.16	–	1.57
5 (B),	4.70	13.14	–	30.24	–	1.47
5 (C),	4.94	14.70	–	16.20	–	–
5 (D),	4.85	13.56	23.60	15.80	11.72	2.07
6 (A),	4.00	12.69	–	23.64	–	–
6 (B),	5.20	13.31	–	25.76	–	–
6 (C),	3.21	11.64	–	21.08	–	–
6 (D),	4.33	11.75	–	23.84	–	–
7 (A),	4.90	12.62	–	27.48	–	–
7 (B),	3.70	13.58	–	26.20	–	–
7 (C),	3.97	14.75	22.93	11.28	11.10	2.35
7 (D),	4.24	11.45	–	18.76	–	–
8 (A),	5.10	11.45	–	25.96	–	–
8 (B),	5.50	12.26	–	22.12	–	–
8 (C),	4.04	11.94	18.77	29.16	–	1.82
8 (D),	4.78	12.81	–	17.92	–	–
9 (A),	5.40	10.69	–	30.04	–	–

Organic Composition of Roots — Continued.

Roots of 1910 — Continued.

Plot and Root.	Moisture.	Protein.	Fiber.	Sugars.	Pentosans.	Fat.
9 (B), ...	6.20	10.58	–	24.08	–	–
9 (C), ...	4.21	14.01	25.10	11.04	11.79	1.87
9 (D), ...	4.65	14.63	21.76	9.56	11.63	2.42
10 (A), ...	5.40	14.26	–	28.32	–	–
10 (B), ...	5.40	11.69	–	33.28	–	1.47
10 (C), ...	3.61	9.63	–	23.64	–	–
10 (D), ...	4.56	13.06	–	29.40	–	–
11 (A), ...	4.20	13.62	–	30.68	–	–
11 (B), ...	5.40	11.20	–	30.44	–	–
11 (C), ...	4.03	11.05	16.35	32.84	–	1.77
11 (D), ...	4.27	13.39	–	30.88	–	–
12 (A), ...	5.20	11.23	–	32.64	–	–
12 (B), ...	5.30	13.50	17.36	33.28	–	1.22
12 (C), ...	3.62	13.62	–	27.48	–	–
12 (D), ...	3.59	11.26	–	28.12	–	–
31 (A), ...	4.95	10.13	–	39.48	–	–
31 (B), ...	4.48	8.41	–	32.40	–	–
31 (C), ...	3.42	10.51	–	–	–	–
31 (D), ...	3.28	10.56	–	30.88	–	–
32 (A), ...	3.47	10.80	–	31.12	–	–
32 (B), ...	3.54	11.75	–	32.84	–	–
32 (C), ...	4.70	12.00	–	27.04	–	–
32 (D), ...	4.93	13.25	–	23.20	–	–
33 (A), ...	3.63	10.33	–	34.60	–	–
33 (B), ...	3.60	12.08	–	29.25	–	–
33 (C), ...	4.55	9.37	–	33.08	–	–
33 (D), ...	4.42	11.94	–	25.32	–	–
34 (A), ...	3.58	12.91	16.83	30.68	10.71	1.30
34 (B), ...	3.49	12.92	15.83	41.36	9.87	1.37
34 (C), ...	4.67	11.25	–	30.88	–	–
34 (D), ...	4.90	11.82	–	29.60	–	–
35 (A), ...	3.69	12.08	–	33.70	–	–
35 (B), ...	3.42	11.69	–	38.92	–	–
35 (C), ...	4.88	11.04	–	35.88	–	–
35 (D), ...	4.00	13.38	–	39.60	–	–
36 (A), ...	2.58	12.63	17.24	34.30	–	1.72

Organic Composition of Roots — Concluded.

Roots of 1910 — Concluded.

Plot and Root.	Moisture.	Protein.	Fiber.	Sugars.	Pentosans.	Fat.
36 (B), ...	5.53	10.51	17.83	28.32	-	1.40
36 (C), ...	4.19	11.40	-	29.80	-	-
36 (D), ...	4.27	11.94	-	25.76	-	-
37 (A), ...	4.49	11.31	-	35.24	-	-
37 (B), ...	4.74	13.44	-	32.00	-	-
37 (C), ...	3.40	11.50	-	33.28	-	-
37 (D), ...	4.18	10.69	-	35.44	-	-
38 (A), ...	3.95	13.94	-	39.80	-	-
38 (B), ...	4.32	12.37	-	36.96	-	-
38 (C), ...	3.96	15.70	-	25.32	-	-
38 (D), ...	4.41	11.20	-	36.12	-	-
39 (A), ...	4.28	10.87	-	37.30	-	-
39 (B), ...	4.64	14.63	-	35.04	-	-
39 (C), ...	3.69	9.94	-	33.28	-	-
39 (D), ...	3.54	12.19	-	26.60	-	-
40 (A), ...	3.42	9.56	-	38.08	-	-
40 (B), ...	3.51	7.81	17.13	38.20	9.04	1.22
40 (C), ...	3.25	6.32	-	33.08	-	-
40 (D), ...	3.70	7.32	-	35.04	-	-

Effects of Fertilizers on Asparagus Stalks.

An attempt was made to determine the effect of fertilizers on the composition of the young stalks, and on that of the tops in midsummer and late fall.

On May 13, 1910, the day's crop from each of four plots in the Concord field was shipped by Mr. Prescott to the laboratory at Amherst. The four samples represented three plots dressed with the maximum amount of nitrogen and one plot which received no nitrogen. The analyses were limited to determinations of dry matter, ash and total nitrogen, and the results were as follows: —

	With Nitrogen.			No Nitrogen, Plot 40.
	Plot 37.	Plot 38.	Plot 39.	
Dry matter, ...	7.00	6.50	6.80	6.10
Ash in dry matter, ...	10.14	10.57	9.81	10.76
Nitrogen in dry matter, ...	4.72	4.55	4.57	4.49

There was a small variation in favor of the plots dressed with nitrogen in both nitrogen and dry matter.

On May 17, 1911, a series of samples was collected in a similar manner from the home field in Amherst, where the material could be prepared for drying as soon as cut. These samples represented one plot without nitrogen, one without phosphoric acid, one without potash and one with a complete fertilizer. Nitrogen and dry matter were determined, and the figures are arranged below.

	No Nitrogen.	No Phosphoric Acid.	No Potash.	Complete Fertilizer.
Dry matter,	8.04	7.50	7.61	7.57
Nitrogen in dry matter,	5.33	5.31	5.17	5.47

In this series there was again a slight gain in nitrogen in the sample from the plot receiving a complete fertilizer, but there was no effect on the dry matter.

On June 1, June 8 and June 14 the entire day's crop from each of four plots was saved and analyzed. These plots represented variations in quantities of nitrogen, phosphoric acid and potash applied as a dressing. The results are shown below for dry matter and nitrogen.

Plot.	Dry Matter.			Nitrogen in Dry Matter.		
	June 1.	June 8.	June 14.	June 1.	June 8.	June 14.
N+P+K,	7.61	7.65	7.72	5.00	4.72	4.61
2N+P+K,	7.49	7.70	7.73	4.89	4.77	4.37
N+2P+K,	7.62	7.63	7.51	5.12	4.87	4.68
N+P+2K,	7.91	7.84	7.90	4.98	4.67	4.84

There was little effect on the composition of the young stalks to be perceived by comparing the results of the first plot with those of each of the other plots. The dry matter varied within narrow limits, while the nitrogen showed a progressive decrease as the season advanced, which was independent of the fertilizers. There was a slight but consistent advantage shown by the double quantity of potash on dry matter results from the last plot.

Effects of Fertilizers on Asparagus Tops.

The period immediately following blooming was chosen as one of the stages of growth at which to study the effect of fertilizers on the development of reserve material in the tops for translocation to the roots. Up to this period the asparagus plant increases steadily in size, and presumably

draws continuously through its roots on the soil for its required mineral matter while building up its organic matter in its green branches. There has been probably but little transfer of sugars and proteins to the roots during this growing time, and it seemed as if any effect of the fertilizers on the formation of those constituents should be perceptible at this season.

The material for this study was gathered from the experiment field at Concord by the selection of samples of tops from eight of the fertilizer plots, which represented wide variations in the method of fertilization. In order to disturb the subsequent growth of these plots as little as possible, not more than one stalk was removed from any plant. Each sample consisted of six stalks selected from as many typical plants on a plot. The samples were weighed immediately after being gathered, and were then packed in burlap sacks for shipment to the laboratory at Amherst. The samples were gathered on Aug. 13, 1912, and were delivered at the laboratory forty-eight hours later.

On the arrival of the samples at the laboratory they were again weighed and were found to have lost 13 per cent. of their field weight, of which loss a large part must have been due to respiration and the consequent destruction of sugars. The branches were cut from the main stalks, and the latter broken in short pieces to facilitate drying, which was carried out by spreading the samples on benches in the greenhouse. It was not possible to dry all the samples simultaneously in the oven, so the greenhouse was selected as providing uniform conditions for them. At the end of five days each sample was cut into short lengths by a fodder cutter, after which a small subsample was separated by quartering.

The small samples were next dried in the oven until they were in a condition to be easily ground, when they were pulverized and passed through a millimeter sieve.

Weights of Samples of Green Tops (Pounds).

Plot 1,	5.25
Plot 5,	6.60
Plot 9,	5.25
Plot 11,	6.75
Plot 31,	6.25
Plot 32,	6.25
Plot 34,	6.15
Plot 35,	5.65

The absence of nitrogen on plot 1 and of potash on plot 9 was accompanied by the lightest weights of samples. Plots 11 and 34 received equal amounts of the complete fertilizer in the spring, and their samples exceeded in weight those of 1 and 9. The absence of phosphoric acid from plot 5 did not affect the weight.

Just before the needles had dropped in the fall was selected as another stage at which to study the effect of the fertilizers on the composition of the tops and on the development of reserve material. For this purpose Mr. Prescott was asked to procure some samples from the Concord field.

In accordance with our instructions Mr. Prescott selected four average plants on each of the plots from which a sample was desired, and removed the entire tops from the crowns. Each plot sample was wrapped in paper and then put in a jute sack for shipment to the laboratory.

The samples arrived at the laboratory on October 23 with the outer sacks somewhat wet as though rained upon, which was not unlikely since the period was especially rainy. On opening the sacks the tops were found to be damp, and a slight mold was observed on some of the twigs. The material was cut into short lengths with a fodder cutter and spread above the steam coils in the greenhouse.

A few days later the samples were quartered and the subsamples were dried in the steam-heated oven until they could be readily ground and sifted.

Partial Composition of Asparagus Tops.

Midsummer Tops.

	Plot 1.	Plot 5.	Plot 9.	Plot 11.	Plot 34.
Ash in dry matter,	10.61	9.00	8.55	9.21	9.69
Protein,	17.87	17.00	17.44	17.56	18.50
Fiber,	32.62	33.62	31.58	34.34	–
Ether extract,	2.46	2.70	3.04	2.66	–
Sugars,	5.11	5.32	6.33	4.41	4.96
Late Fall Tops.					
Ash in dry matter,	12.12	7.84	6.68	–	8.97
Protein,	8.44	8.31	7.50	–	8.62
Fiber,	41.89	44.93	46.30	–	41.23
Ether extract,	3.68	3.28	3.56	–	3.40
Pentosans,	20.71	21.44	21.60	–	20.14

Partial Composition of Asparagus Tops.

Midsummer Tops.

	Plot 31.	Plot 32.	Plot 34.	Plot 35.
Ash in dry matter,	9.58	10.33	9.69	8.70
Protein,	17.44	17.12	18.50	17.94
Sugars,	5.66	5.00	4.96	3.75
Late Fall Tops.				
Ash in dry matter,	8.90	7.95	8.97	8.06
Protein,	8.12	7.50	8.62	7.06
Pentosans,	20.46	21.15	20.14	20.83

Plot 1 lacked nitrogen, plot 5 lacked phosphoric acid and plot 9 lacked potash. Plots 11 and 34 received the complete fertilizer in medium amount. Plots 34 and 35 received one and one-half times the amount of nitrogen that was applied to 31 and 32. Plots 31 and 34 received their nitrogen in the early spring, while 32 and 35 had their portions applied in late June.

The high ash occurring in both seasons in the tops from plot 1 was apparently due to fine earth which adhered to them, as there was much insoluble residue after testing the ash with strong acid. On the other hand, the samples from plot 9 showed a low ash, which was without doubt due to the lack of potash.

The development of protein and sugar was not perceptibly affected by the lack of fertilizers, since there is no consistent relation between the percentages and the amounts.

A comparison of the two pairs of plots which received nitrogen at different seasons shows that the tops from the plots dressed with nitrates in summer contained slightly less protein than those from the plots dressed in the spring. This was also the result on the single pair of plots (37 and 38) from which the young stalks were sampled in 1910. With the two pairs of plots under comparison there was a slight advantage in the amounts of protein found in the tops from the larger quantities of nitrogen.

The effect of fertilizers on the proportions of inorganic constituents in the different stages of tops was not studied because the slight effects produced on the roots did not warrant such a laborious comparison.

Effect of Fertilizers on Asparagus Roots at the End of the Cutting Season.

The summer samples of roots were dug from plots receiving two different quantities of nitrogen at two different seasons for the purpose of measuring whether the exhaustion of the roots during the growth of the crop was influenced by amount or season of application of nitrate of soda. Plots 34 and 35 received one and one-half times as much nitrogen as 31 and 32, while 31 and 34 received it in the spring and 32 and 35 in the summer.

Total nitrogen and sugar showed consistent variations relative to the different treatments, but none of the other constituents could be correlated and are not tabulated.

The roots dressed with the larger amount of nitrogen contained higher percentages of nitrogen and sugar than those which received the smaller amount. Roots receiving their nitrogen in summer after the cropping season still contained a little more nitrogen than the others. Sugar, however, was more exhausted than in the roots which had received their nitrogen in spring.

Comparative Effects of Spring and Summer Top-dressing on Asparagus Roots at End of Cutting Season.

Plot and Root.	Fresh Weight (Grams).	Per Cent.		
		Dry Matter.	Total Nitrogen.	Total Sugar.
31 (I.),	600	17.15	1.37	22.40
31 (II.),	2,744	21.37	1.78	34.54
31 (III.),	1,995	18.52	2.24	19.92
31 (IV.),	1,970	19.77	1.86	26.17
Average,	1,825	19.20	1.81	25.76
32 (I.),	1,400	16.04	1.94	19.60
32 (II.),	2,060	15.87	2.06	7.68
32 (III.),	3,830	14.43	2.47	7.40
32 (IV.),	3,375	19.97	1.79	18.53
Average,	2,666	16.58	2.06	13.30
34 (I.),	2,750	17.88	1.84	26.43
34 (II.),	3,150	19.81	1.80	32.67
34 (III.),	3,400	20.58	2.22	36.14
34 (IV.),	1,805	15.59	2.33	16.13
Average,	2,776	18.46	2.06	27.84
35 (I.),	2,945	18.88	2.12	29.87
35 (II.),	860	23.14	2.22	31.17
35 (III.),	3,180	21.25	2.18	26.70
35 (IV.),	2,355	17.67	2.10	15.27
Average,	2,335	20.24	2.15	25.90

Sugar fluctuated widely in individual roots, and the value of the averages is somewhat doubtful.

The weights of roots from the same plot vary as widely as the weights from different plots, so that no conclusions can be drawn from the size of roots.

The general effect of varying the season of top-dressing with nitrate of soda was very small and inconclusive.

Reserve Material required to produce a Crop of Young Stalks.

An attempt is here made to determine the amount of reserve material drawn from the roots during the spring cutting season. For this purpose use is made of the average composition of fall roots, spring stalks and summer roots, and the average weights obtained from the four plots

numbered, respectively, 31, 32, 34 and 35 of fall roots, summer roots and the spring crop of stalks.

The calculated results are necessarily approximate because identical roots cannot be analyzed at two successive stages of growth, but the comparison suggests possibilities if not absolute conditions.

The average weights of roots were obtained from the samples collected in 1910 and 1911. The average weight of the crop of stalks is calculated from the total weights cut on the four plots in 1911. The number of plants per plot was originally 250, but four roots were removed in 1908 and four more in 1910.

Grams of Constituents in Roots and Crop of an Average Plant.

	Autumn Roots, 1910.	Summer Roots, 1911.	Spring Crop, 1911.
Green weight,	2,393.00	2,401.00	447.00
Dry matter,	504.90	447.00	34.40
Total sugar,	159.24	103.70	5.23
Fiber, pentosans and lignin,	239.22	239.10	22.25
Fat,	8.93	7.28	1.05
Protein,	62.81	56.99	10.52
Ash,	34.78	39.91	2.97
Total nitrogen,	10.05	9.12	1.68
Protein nitrogen,	5.35	5.81	1.05
Amino nitrogen,	4.70	3.31	.63
Potassium oxide,	12.44	10.61	1.80
Sodium oxide,	1.85	1.63	.11
Calcium oxide,	1.81	1.95	.13
Magnesium oxide,	.97	.82	.12
Phosphoric acid,	2.34	1.97	.18
Sulfuric acid,	3.12	3.26	.28

The average weight of crop per plot was 238.6 pounds (108.3 kilos) which, divided between 242 plants, gave a little less than a pound, or 447 grams, per plant.

When the combined weights of the different constituents of summer roots and spring crop were balanced against the weights of the same constituents in the autumn roots there was noted a marked loss in organic matter and a pronounced gain in inorganic matter.

The loss of organic matter was confined almost wholly to the sugar, as there was but a small deficit in the quantity of fat. The total carbohydrate matter in the spring crop amounted to 27.48 grams, while the difference between the quantities of sugar in the autumn and summer roots was 57.54 grams. There was an increase in protein of 4.7 grams

over the amount present in the autumn roots, which might require a little of the sugar in its synthesis; but, on the other hand, the study of the progressive changes in composition of young stalks indicated that they synthesized a part of their sugar before they were of marketable size. Therefore the comparison in this case showed that for every gram of carbohydrate developed in the young stalk at least two grams disappeared from the parent root, one of which must have been used in maintaining the energy of the growing plant, just as the young animal uses a large part of its food in maintaining its body energy.

The gain in protein during the growth of the crop is of interest in connection with the problem of nitrogen fertilization. The transfer of nitrogen from the autumn root to the growing stalk was apparently accomplished by using only the amino nitrogen of the reserve in the parent crown, and drawing on the soil nitrogen. The increase in nitrogen of summer roots and crop over the amount in the autumn roots is .75 gram, or 7.5 per cent., and is not of sufficient amount to show the necessity of a spring application of nitrogen.

The gain in ash was confined to calcium oxide and sulfuric acid of the determined constituents, while a part of the variation was undoubtedly due to the very fine sand of the soil which had escaped the cleaning process to which roots and stalks were subjected.

Calcium oxide and sulfuric acid gained, respectively, .27 gram and .42 gram, or 14 per cent. and 13 per cent. Potassium oxide and magnesium oxide were almost exactly balanced on the two sides, while sodium oxide and phosphoric acid had slight amounts unaccounted for, which may have been due to the difficulties in exact determinations of these constituents in organic substances.

These comparisons show but little, if any, immediate effect on the spring crop of a spring application of fertilizers. There was a slight apparent absorption of nitrogen, a more marked intake of lime and sulfuric acid, perhaps in combination, and no apparent use at this period of potash and phosphoric acid. But as already remarked, these comparisons can be regarded as merely suggestive.

Amount of Vegetable Matter contained in Ripened Asparagus Tops.

The method of asparagus culture now followed by many growers in Massachusetts leaves the tops to die down in the autumn and in the spring works them into the soil by means of a disc harrow. On the experiment field a number of the plots have received no annual dressing of manure, and the humus in the soil has been replenished only by the annual growth of tops.

In the autumn of 1912 Mr. Prescott was requested to determine the weights of the ripened tops on several plots that had received only chemical fertilizers. Mr. Prescott selected one rod of row on each plot, where

there were seven consecutive plants to the rod. The stalks were cut level with the ground and weighed.

This work was done in the last week in October when the sap had mostly left the stalks.

The weights per plot were as follows: —

Weights of Tops per Rod of Row, Autumn of 1912 (Pounds).

Plot 1, without nitrate of soda,	3.5
Plot 3, complete fertilizer,	5.5
Plot 5, without acid phosphate,	4.0
Plot 7, complete fertilizer,	4.0
Plot 9, without muriate of potash,	4.0
Plot 11, complete fertilizer,	6.5
Plot 34, complete fertilizer,	4.0
Plot 40, without nitrogen,	3.0
Average,	4.3

At the rate of 250 plants per plot, or 5,000 plants per acre, these results from 7 plants would give 3,071 pounds of dying tops per acre. Samples of stalks gathered early in November at Amherst contained 49 per cent. of dry matter, by which it is estimated that there were about 1,500 pounds per acre of dry vegetable matter added to the soil of the asparagus field per year.

Rousseaux and Brioux [1] report, as the result of five different fields in France, a range of from 891 to 2,128 kilos per hectare for the dry matter in the crops of the tops removed in late autumn from the fields, in accordance with French practice. Their average dry matter per hectare was 1,579 kilos, or about 1,400 pounds, per acre.

In percentage of soil per acre this amount of tops is really small. On such sandy soil as the Concord field the tops would be worked into the surface 4 inches, or mixed with approximately 1,000,000 pounds of soil, which would enrich the soil with not more than .15 per cent. of organic matter. Nevertheless, several of the best plots in the experiment field have received no more organic matter than is contained in the tops, which is a good illustration of the effectiveness of small annual additions of organic matter to our soils.

Relation of Asparagus Roots to Weights of Stalks.

It was expected that there would be a close relationship found between the size of roots from a plot and the total weight of stalks cut from it, and an attempt was made to correlate the weights of sample roots in 1910 with the weights of crops over a period of five years.

In the phosphate group of plots, 5, 6, 7 and 8, the smallest roots were obtained from the plot that received no phosphate in the top-dressing; but the crop yields were not invariably the lowest in the series. Plot 8, which received the maximum dressing of acid phosphate, yielded much

[1] Annal. d. Sci. Agron., 1906, pp. 188-326.

smaller roots than plots 6 and 7, but its crop yield was the maximum in every year but the fifth, when its yield was exceeded by plot 7 with a fraction of a pound.

The weight of roots in the potash group of plots numbered 9, 10, 11 and 12 increased from 9 without potash to 11 with a medium application. The yield of stalks followed the same order each year.

The nitrate of soda group included ten plots numbered 31 to 40, inclusive. The weights of individual roots from any one plot varied considerably from the average for that plot, but the plot averages showed fairly consistent changes in size of roots with amount of nitrogen applied in the top-dressing. The weights of roots from plots 31, 32 and 33 were, respectively, smaller plot by plot than the weights of roots from plots 34, 35 and 36. The weights of crops did not follow the same order, but were in several instances reversed.

The application of nitrate of soda in the spring on plots 31, 34 and 37 resulted in much larger roots than the summer dressing apparently produced on 32, 35 and 38. On the other hand, the weights of crops from the summer-dressed plots were in nearly all cases the larger. Plot 40 without nitrate yielded roots no lighter in weight than plot 39, which received a maximum dressing of nitrate of soda, divided between spring and summer. The yield of stalks was, however, much smaller on plot 40 than on 39. The small roots with large yields contained higher percentages of nitrogen than the roots bearing smaller crops, so there was difficulty in correlating roots with crops of stalks, since the variations in proportions of root constituents were possible factors in influencing growth of stalks.

Weight of Asparagus Stalks cut in the Spring (Pounds).[1]

Plot.	Application.	1910.	1911.	1912.	1913.	1914.
5	No phosphate,	232.3	221.1	270.9	388.0	404.2
6	Minimum phosphate,	241.4	221.1	273.4	385.8	420.4
7	Medium phosphate,	241.6	240.4	281.1	387.7	436.9
8	Maximum phosphate,	252.8	251.6	298.4	403.3	436.4
9	No potash,	208.6	210.6	258.6	324.0	366.7
10	Minimum potash,	237.2	237.3	284.7	373.6	408.4
11	Medium potash,	276.5	289.9	342.0	446.8	478.9
12	Maximum potash,	262.7	269.6	302.8	409.8	458.5
31	Minimum nitrate, spring,	220.9	223.7	272.4	375.1	395.7
32	Minimum nitrate, summer,	221.3	242.2	284.4	401.6	406.3
33	Minimum nitrate, half in spring, half in summer,	222.6	239.7	291.2	378.4	389.8
34	Medium nitrate, spring,	214.2	240.6	288.0	381.9	378.6
35	Medium nitrate, summer,	216.0	247.8	288.9	368.3	368.5
36	Medium nitrate, half in spring, half in summer,	210.2	224.2	268.5	357.4	362.2
37	Maximum nitrate, spring,	193.9	223.2	283.8	345.2	340.9
38	Maximum nitrate, summer,	196.2	234.9	303.0	367.1	347.5
39	Maximum nitrate, half in spring, half in summer,	214.2	230.7	288.4	358.6	351.6
40	No nitrate,	181.2	202.2	263.4	307.5	314.3

[1] For Table of Weights of Roots see p. 278, series of 1910.

Summary.

During the earlier years of the asparagus field the crowns and roots steadily increased in size, doubling in weight between the second and fourth years after setting. The proportion of protein remained nearly constant in the dry matter of the roots during the period observed, while the sugar decreased and the cellulose and allied compounds increased.

The composition of the young stalks cut in the spring changed as the cutting season advanced. Dry matter was practically constant, but sugar increased in proportion while protein decreased somewhat.

The development of the asparagus tops to maturity was accompanied by a continuous increase in the cellulose and its related groups, — pentosans and lignin. Protein and sugar decreased in their proportions, but were not wholly translocated to the roots from the ripened tops.

Water was the dominant constituent of the asparagus plant in all the stages studied. It was highest in the young stalks. The summer or growing roots were a little more watery than the late fall or storage roots.

Calcium oxide and sulfuric acid steadily accumulated in the asparagus tops as they grew old, but potash and phosphoric acid were transferred either to the fruit or back to the roots.

Withholding one of the constituents of a complete fertilizer from the annual top-dressing was accompanied by a smaller average weight of roots in the samples taken from the plot thus treated. Withholding nitrate of soda lessened the percentage of nitrogen and of soda in the roots; withholding muriate of potash lessened the proportion of potash in the roots; withholding acid phosphate produced no apparent change in the constituents of the roots.

An increase of nitrate of soda from the minimum to the medium amount in the top-dressing caused an increase in the percentage of nitrogen in the dry matter of the roots.

An increase in the amount of muriate of potash produced some increase in the percentage of potash in the roots.

Asparagus roots taken from plots receiving the nitrate of soda in the spring were noticeably heavier in weight and a little poorer in nitrogen than roots from plots that were top-dressed with nitrate in the summer.

During the cutting season the production of young stalks drew most heavily on the sugar contained in the roots, but there was no approach to exhaustion of that constituent. Fully twice as much sugar was consumed as would have been required to produce the carbonaceous matter in the young stalks.

The roots apparently absorbed nitrogen, lime and sulfuric acid during the cutting season. Potash and phosphoric acid were apparently supplied to the young stalks wholly from the reserves in the roots.

Practical Conclusions from the Chemical Study of the Asparagus Plant.

Asparagus roots that had been set in the spring of 1907 were found to have doubled in size and weight between November, 1908, and November, 1910. During this period of rapid growth the percentages of the different fertilizing constituents in the dry matter remained constant or else increased slightly.

Absence of nitrogen, phosphoric acid or potash from the annual top-dressing was found to limit the growth of the roots.

Withholding nitrate of soda from the top-dressing, or applying it in relatively small amounts, resulted in lessening the percentages of nitrogen in all parts of the plant.

A complete fertilizer rich in nitrogen is clearly shown to be required in generous amounts in order to produce a continuous strong development of the asparagus plant.

Water is of prime importance in all parts of the asparagus plant at all stages of growth. It is especially important in the spring months during the cutting season, since the young stalks contain about 92 per cent. of water, while the roots at this period are more watery than in the fall. The physiological need of water, together with the sandy quality of most asparagus soils, indicates that irrigation would be advantageous if not necessary in the production of maximum crops.

The reserve material stored in autumn in the roots was found to be principally sugars. Sugars were also prominent in the spring stalks and both summer and fall tops. The synthesis of sugar in the tops and its translocation to the roots appeared to continue until the tops were killed by frost.

Destruction of the tops by rust, or their premature removal to be rid of the berries, must lessen the amount of sugar which can be stored in the roots.

The fertilizing constituents which were stored in the roots over winter appeared to be nearly, if not quite, sufficient for the full development of the succeeding spring crop. There was evidence of a small intake of nitrogen during the cropping season, and a pronounced absorption of lime and sulfuric acid.

Sulfuric acid was found to be equally, if not more, important than phosphoric acid among the constituents of the asparagus plant. Nevertheless, the sulfate of lime in the acid phosphate appeared to suffice fully for the needs of the crop.

BULLETIN No. 172.

DEPARTMENT OF CHEMISTRY.

EXPERIMENTS IN KEEPING ASPARAGUS AFTER CUTTING.

BY F. W. MORSE.

The object of this experiment was to determine some of the changes which take place in asparagus from the time when it is cut in the field until it is ready to be cooked. This period varies from a few hours to several days, and during it there is seldom any care taken to preserve the asparagus stalks in a fresh, crisp condition. Sometimes the stalks are kept with their butts in water; but this is not a general practice among the dealers in this vegetable.

Fruits and vegetables are living things and life is maintained by respiration, which requires a supply of food just as with animals. When animals fast they lose weight because their body material is used in respiration. When vegetables and fruits are removed from the plants on which they grew they steadily lose in weight because of respiration, and their chemical composition continually changes.

Experiments with apples[1] have clearly shown that after the fruit is picked from the tree respiration is maintained by which carbon dioxide and water are continually exhaled, while analysis has proved that sugar steadily diminishes and the fruit loses in weight. It was found, too, that low temperatures slowed down the respiration while high ones speeded it up, and that retarding respiration was an important factor in the preservation of fresh fruits.

Besides investigating the nature of the change in asparagus after it has been cut from the plant, the effects of high and low temperatures on the rate of change have been studied as an important part of the experiment.

The following table[2] gives the average composition of asparagus stalks when prepared for analysis as soon as practicable after they were cut from the plants: —

TABLE I.

Composition of Asparagus Stalks when Fresh (Per Cent.).

Water,	92.30
Dry matter,	7.70

[1] F. W. Morse: The Respiration of Apples and its Relation to their Keeping. Bul. 135, N. H. Agr. Expt. Sta., 1908, 8 pp.

[2] Bul. 171, Mass. Agr. Expt. Sta., p. 274.

Per Cent. in Dry Matter.

Ash,	8.69
Protein,	30.77
Fiber,	18.20
Fat,	3.07
Total sugars,	15.22
Reducing sugars,	11.17
Pentosans,	13.41
Lignin, etc.,	10.64

It will be noted that the succulent stalks contained over 92 per cent. of water, and that protein, fiber and sugar were the most abundant constitutents of the dry matter. Fiber forms the framework of the stalks, while the protein and sugar are the substances utilized most freely by the cells for food and growth. The two latter substances were studied as the means of determining the kind and rate of change occurring in the asparagus after cutting.

Several experiments were conducted, each one varying a little in detail from its predecessor; therefore each experiment will be separately described.

Two were conducted in 1914 and the remainder in 1916.

Experiment 1. — This experiment was begun May 25, 1914. A quantity of stalks was brought to the laboratory immediately after they were cut in the field. Each stalk was rinsed clean from adhering soil and wiped dry with a towel. The lot was then divided into three bunches of uniform size and appearance, and each bunch was weighed and placed under its assigned conditions.

One bunch, A, was prepared at once for quick drying. The stalks were broken into pieces 2 to 3 inches long, which were spread in a single layer on a tray and placed in a large drying oven. The oven was heated by a steam coil which maintained a temperature between 50° and 60° C. This heat was sufficient to expel the water from the succulent stalks without softening them, as in cooking.

The second bunch, B, was set in a jar with the butts in shallow water and left in the laboratory where the temperature would remain at summer heat, or from 70° to 80° F. day and night.

The third bunch, C, was loosely wrapped in paper and laid on the shelf in a refrigerator of the usual family size, kept well supplied with ice, which held the temperature between 45° and 50° F.

At the end of three days (seventy-two hours), bunches B and C were again wiped dry with towels and weighed, after which they were prepared for the drying oven in the same manner as A.

B was firm and brittle and had increased in weight over 15 per cent. by imbibing water. C was somewhat limp but not withered, and had lost a little over 3 per cent. of its original weight.

When dried to a condition which permitted the asparagus to be easily ground to a powder, the samples were removed from the large oven,

weighed and pulverized. The samples were then analyzed for absolute dry matter, total sugar, reducing sugar, protein, protein nitrogen and amino nitrogen, and the results are arranged in Table II.

TABLE II.

	A.	B.	C.
Weight fresh (grams),	823	804	803
Weight after keeping (grams),	–	927	776
Per Cent. calculated on Fresh Weight.			
Water,	92.36	93.20	92.75
Dry matter,	7.64	6.80	7.25
Per Cent. in Dry Matter.			
Total sugars,	20.55	10.41	14.11
Reducing sugars,	14.25	9.94	10.10
Total protein,	29.33	34.33	30.75
Protein nitrogen,	3.72	3.28	4.01
Amino nitrogen,	.97	2.21	.91

Experiment 2. — This experiment was begun June 2, 1914, and was carried out as nearly as possible in the same manner as Experiment 1, and the data are given in Table III.

TABLE III.

	A.	B.	C.
Weight fresh (grams),	715.5	719.5	719.0
Weight after keeping (grams),	–	836.0	698.5
Per Cent. calculated on Fresh Weight.			
Water,	92.32	93.19	92.72
Dry matter,	7.68	6.81	7.28
Per Cent. in Dry Matter.			
Total sugars,	27.39	12.41	18.91
Reducing sugars,	20.29	7.46	12.68
Total protein,	28.46	32.90	31.39
Protein nitrogen,	3.49	3.57	3.92
Amino nitrogen,	1.06	1.69	1.10

Although B imbibed water and increased in weight, there was really greater destructi n of dry matter than in the bunch C, which was kept in the refrigerator. The actual amount of change under each condition is shown on tl.e basis of 100 parts of fresh asparagus in Tables IV. and V.

TABLE IV. — *Experiment 1.*

	A.	B.	C.
Dry matter (per cent.),	7.64	6.80	7.25
Sugar (per cent.),	1.57	.71	1.02
Protein (per cent.),	2.24	2.34	2.23

Protein was little changed, but sugar was partly destroyed. The loss of sugar was a little in excess of the loss of dry matter.

TABLE V. — *Experiment 2.*

	A.	B.	C.
Dry matter (per cent.),	7.68	6.81	7.28
Sugar (per cent.),	2.10	.84	1.37
Protein (per cent.),	2.19	2.24	2.28

There was a marked change in the relative proportions of protein nitrogen and amino nitrogen in B in both experiments, as shown in Tables II. and III. The chemical activity changed the form of nitrogen compounds but not their total amount, as shown in Tables IV. and V.

The work was not continued in 1915 on account of other investigations that seemed more important. In the spring of 1916 the investigation was resumed and several different experiments were conducted.

Experiment 3. — This experiment was begun May 29, 1916. This lot of stalks was brought to the laboratory from the plots as soon as cut. The plots had not been cut over for two days and the stalks were too tall and the heads had begun to open too much for good marketable asparagus. The stalks were washed and scrubbed with a brush to remove all adhering soil, and wiped dry with towels. The lot was then separated into five bunches as uniform as possible in appearance, after which each bunch was weighed and placed under its assigned conditions.

A was broken in short pieces, spread on a tray and placed in the oven at a temperature between 50° and 60° C. B was set upright in a jar with the butts in water and left in the laboratory at the room temperature. C was wrapped loosely in paper and laid on the shelf beside B. D was laid directly upon the cake of ice in the refrigerator. E was stood upright

in a jar with its butts in water and set in the food compartment of the refrigerator.

At the end of forty-eight hours bunches B, D and E were unbound and the stalks were wiped with towels. C, having been kept dry, needed no such dr ing. Each bunch was then weighed, after which it was prepared and put in the oven as A had been.

The stalks in B were firm and crisp, but the heads were much opened. The stalks in C were limp and slightly withered, and a few would not break, but were cut into the proper lengths for drying. Those in D, lying directly on the ice, were somewhat limp but unwithered, while those in E, standing in the water, were plump and firm, and the heads were unchanged in appearance. Both B and E had imbibed water, but B had gained almost 15 per cent. in weight, while E had gained only 10 per cent. C and D both lost weight; the former shrunk 21.7 per cent., while the latter lost only 3.7 per cent.

Dry matter and total sugar were the only determinations made after the dried stalks were pulverized for analysis.

TABLE VI.

	Weight Fresh (Grams).	Weight after Keeping (Grams).	Dry Matter from Fresh Weight (Per Cent.).	Total Sugars from Dry Matter (Per Cent.).
A, ...	677	–	6.72	15.96
B, ...	654	751	6.47	12.14
C, ...	590	512	6.30	12.35
D, ...	714	688	6.65	14.63
E, ...	633	697	6.49	11.23

Experiment 4. — This experiment was begun June 5, 1916. The material was much like that of the previous experiment, — a little too much developed for the best marketable condition. The stalks were washed and dried and arranged in five bunches which were subjected to conditions like those of Experiment 3. B and C were held but twenty-four hours, while D and E were continued throughout four days (ninety-six hours). B, in twenty-four hours, imbibed water and increased in weight 16.8 per cent. E, in four days, increased 13.7 per cent. Of the bunches kept dry, C, in the warm room, lost 8.2 per cent. in twenty-four hours, and D, on the ice, lost 5.4 per cent. in four days.

The determinations in the dried material were confined to dry matter and sugar.

TABLE VII.

	Weight Fresh (Grams).	Weight after Keeping (Grams).	Dry Matter from Fresh Weight (Per Cent.).	Total Sugars from Dry Matter (Per Cent.).
A,	528	-	7.50	20.60
B,	534	624	7.18	16.31
C,	549	504	7.31	17.34
D,	589	557	7.34	17.91
E,	544	619	7.20	17.99

Experiment 5. — The stalks were brought to the laboratory on the morning of June 15, 1916. The weather for two days had been cooler than usual, so that the asparagus had grown less rapidly than at the time of the two previous trials. The stalks were about 10 inches long, with close heads. The lot was divided into six bunches, A, B, C, D, E and F.

As usual, A was prepared for the drying oven at once. The other five bunches were stood upright in a tin box with a tight cover and with no water in it. The box with its contents was placed in the refrigerator.

The two previous experiments had shown that the asparagus stalks would become limp even when on the ice, unless their butts were in water. The tight box was chosen in order to reduce the evaporation to the lowest point by keeping the stalks in a close atmosphere. This atmosphere was soon saturated with moisture by the exhalations from the stalks, but there was no water for imbibition. The imbibed w ter promotes chemical activity, and the stalks with butts in water, while remaining firm and crisp, actually lose dry matter more rapidly than those held out of water, which become limp, as shown by B and E when compared with C and D, in Tables VI. and VII.

One bunch at a time was removed from the box, at intervals of two to four days.

June 19, four days after cutting, B was taken out. Stalks were firm and crisp, apparently as fresh as when placed in the box. Drops of moisture appeared on the walls of the box and on the stalks. The stalks were wiped dry with a towel and then weighed. After being weighed the stalks were broken and spread on a tray and dried in the oven as usual.

June 21, six days after cutting, C was removed. Stalks were apparently as sound and fresh as B. Subsequent treatment was as usual.

June 23, eight days after cutting, D was removed. The stalks in this bunch were slightly limp, but not as limp as bunches kept on ice for a day or two in the circulating atmosphere of the refrigerator. The bunch was treated as usual.

June 26, eleven days after cutting, E was removed. The stalks were firm and plump, but this may have been due to imbibition of water

through the butts, as there was now a positive accumulation of exhaled moisture on the bottom of the box. The refrigerator temperature held at 45° to 50° F.

June 29, fourteen days after cutting, F was taken out. The stalks were firm and crisp. The butts looked dry and old on their surfaces; but if freshly trimmed by cutting off one-fourth of an inch of their length, the bunch would have passed for freshly cut asparagus. Much moisture had accumulated on the bottom of the box. The stalks were prepared for drying in the usual manner.

The usual determinations of dry matter and total sugar were made in the dried material.

TABLE VIII.

	Weight Fresh (Grams).	Weight after Keeping (Grams).	Dry Matter from Fresh Weight (Per Cent.).	Total Sugars from Dry Matter (Per Cent.).
A,	528	–	6.76	17.76
B,	535	531	6.73	20.20
C,	474	470	6.79	19.39
D,	512	504	6.64	20.65
E,	453	444	6.25	13.79
F,	578	570	6.00	9.87

There was one unaccountable discrepancy in this series, — A had a lower sugar content then B, C or D. There may have been some condition during the first hours of drying this sample which favored the transformation of sugar into some of the lignified matter, but that is mere conjecture. Ordinarily, a lowering in sugar has been accompanied by a pronounced lessening of dry matter, which did not appear in this instance.

Experiment 6. — This experiment was begun June 19, 1916. The stalks were a poor average lot, some having grown too tall and having heads much opened, but a portion of the stalks were in excellent form for market. The lot was divided into four bunches of as uniform quality and size as could be estimated.

Bunch A was immediately prepared for drying in the accustomed manner. The other three bunches were set upright in the tin box with those of Experiment 5, and none of them was removed until July 5, sixteen days after cutting. As a whole, these three bunches were in poor condition when taken out. Some of the tips were attacked by a white mold and some of the butts were soft with decay. Some stalks were shriveled throughout their length. The stalks were wiped dry with towels and weighed. Then all stalks showing signs of decay or mold were rejected from further study, and the remainder was sorted into firm and shrunken lots. Of the original lot of stalks, 34 per cent. was rejected, 35 per cent.

was firm and crisp in appearance, and the remaining 31 per cent. was more or less shrunken or withered.

These latter two lots of stalks were prepared for analysis in the customary manner, and dry matter and total sugar were determined.

TABLE IX.

	Weight Fresh (Grams).	Weight after Keeping (Grams).	Dry Matter from Fresh Weight (Per Cent.).	Total Sugars from Dry Matter (Per Cent.).
A,	519	–	6.24	20.54
B, C, D,	1,769	1,714	–	–
Firm,	–	–	5.32	2.53
Shrunk,	–	–	5.38	3.83

This lot of stalks proved quite inferior in dry matter to any of the other lots; but in total sugar, A was equal to any of the others of this season.

To determine whether the loss of sugars was the only destructive change in the dry matter, the losses of both sugars and dry matter were compared, as shown in Table X. It was noted that in all but two instances, namely, Experiment 3, C, and Experiment 4, E, the loss of sugar slightly exceeded the shrinkage in dry matter. This excess though small was persistent.

TABLE X.

Comparative Losses of Dry Matter and Sugars (Per Cent.).

	Dry Matter.			Total Sugars.		
	Originally.	After Keeping.	Loss.	Originally.	After Keeping.	Loss.
Experiment 1, A,	7.64	–	–	1.57	–	–
B,	–	6.80	.84	–	.71	.86
C,	–	7.25	.39	–	1.02	.55
Experiment 2, A,	7.68	–	–	2.10	–	–
B,	–	6.81	.87	–	.84	1.26
C,	–	7.28	.40	–	1.37	.73
Experiment 3, A,	6.72	–	–	1.07	–	–
B,	–	6.47	.25	–	.78	.29
C,	–	6.30	.42	–	.78	.29
D,	–	6.65	.07	–	.97	.10
E,	–	6.49	.23	–	.73	.24
Experiment 4, A,	7.50	–	–	1.54	–	–
B,	–	7.18	.32	–	1.17	.37
C,	–	7.31	.19	–	1.27	.27
D,	–	7.34	.16	–	1.31	.23
E,	–	7.20	.30	–	1.29	.25
Experiment 5, B, C, D,	6.72	–	–	1.35	–	–
E,	–	6.25	.47	–	.86	.49
F,	–	6.00	.72	–	.59	.76
Experiment 6, A,	6.24	–	–	1.28	–	–
Firm,	–	5.32	.92	–	.13	1.15
Shrunk,	–	5.38	.86	–	.20	1.08

The disappearance of the sugar is probably, in part, a transformation into the cellulose group of carbohydrates. This view was suggested by the work of Mrs. K. G. Bitting, who kindly allowed me to read the proof sheets of her bulletin on "Deterioration in Asparagus,"[1] in which she has shown that asparagus tissues develop increasing areas of lignin when the stalks are kept for twenty-four hours or more after being cut from the crown.

In order to elucidate further the character of the changes in the groups of constitutents in the asparagus, Mr. C. L. Beals determined the crude fiber and fat in the dry matter of the six samples described in experiments 1 and 2. The results are given in per cent. of dry matter and absolute weights calculated in the fresh stalks

TABLE XI.

Per Cent. in Dry Matter.

	A Fresh.	B Kept Warm.	C Kept Cool.
Experiment 1: —			
Fiber,	10.54	15.51	12.71
Fat,	2.74	2.04	2.75
Experiment 2: —			
Fiber,	10.99	17.59	13.01
Fat,	2.85	2.29	2.94

Grams in Fresh Material.

	A Fresh.	B Kept Warm.	C Kept Cool.
Experiment 1: —			
Dry matter,	7.64	6.80	7.25
Fiber,	.80	1.05	.92
Gain,	–	.25	.12
Fat,	.21	.14	.20
Loss,	–	.07	.01
Experiment 2: —			
Dry matter,	7.68	6.81	7.28
Fiber,	.84	1.19	.95
Gain,	–	.35	.11
Fat,	.22	.15	.21
Loss,	–	.07	.01

[1] K. G. Bitting: Bulletin 11, National Canners' Association, Washington, D. C., 1917, 18 pp. 9 plates.

This series of determinations fully corroborated the increase of lignified tissue, as there was a positive gain in the absolute amounts of crude fiber or cellulose in the samples held for three days, which gain was more than twice as great in the warm room. At the same time there was a positive loss of the fatty extract in the warm room, but an almost negligible shrinkage in the refrigerator.

The pronounced destruction of sugar by respiration and the increase of lignified tissue must affect the flavor and tender crispness of the young stalks, and these changes were much lessened by the lower temperatures.

The development of fiber or cellulose at the expense of sugars and fatty matter is a logical consequence of the continued growth of asparagus stalks after they have been cut from the crown. The comparative amounts of this growth at summer temperatures and the cooler ones of the refrigerator have been studied with interesting results.

Freshly cut stalks of asparagus were divided into two lots, one of which was left in a warm room over night, or about ten hours, while the other was placed in the refrigerator for the same period. Both lots of stalks stood with butts in shallow water.

The temperatures of room and refrigerator were noted at the beginning and end of the period, and as neither was opened during the time, it was assumed that the temperatures had remained within the limits noted. The increase in length of each stalk was carefully measured. The total number of stalks used in the different trials was 25. The average results for each trial are tabulated in Table XII.

Table XII.

	Temperature (Degrees F.).	Growth (Millimeters).	Temperature (Degrees F.).	Growth (Millimeters).
June 2,	75–76	12.3	52–56	4.3
June 4,	70–71	14.3	49–54	2.5
June 7,	68–71	11.7	49–54	4.0
June 20,	80	18.6	45	2.6

The average rate of growth in the warm room was more than four times as fast as that in the refrigerator. At no time was the refrigerator cold enough to stop entirely the elongation of the tips, but at 45° F. it was nearly negligible.

Summarizing the results of these varied experiments, it is clear that in Experiments 1 and 2, the changes in the warm room were fully double those in the refrigerator. In Experiment 3, the bunches in the warm room changed three times as fast as the bunch on ice. In Experiment 4, the bunches in the warm room changed more in one day than those in the refrigerator changed in four days. In Experiment 5, the asparagus changed very little in a week, when kept in a close atmosphere in the

refrigerator. Experiment 6 showed that two weeks was too long a period to hold asparagus under the conditions.

In conclusion, the experiments clearly show the possibility of holding asparagus for a week with very little deterioration in quality, by keeping the stalks at a low temperature and in a close atmosphere with little air circulation. The temperature should be as low as 45° F. if possible, as this point is about the lowest limit for plant growth to take place, although respiration, or the destruction of sugar, will still persist.

Experiments on a commercial scale have not been tried, but the feasible plan appears to be as follows: cool the asparagus as soon as possible after cutting. Lay the stalks loosely in boxes, place on ice in the icehouse and cover with canvas to maintain a low temperature and reduce the circulation of air. The common market boxes would probably allow any moisture exhaled and later condensed to drain off and not accumulate in the bottom of the box. Under this treatment the asparagus should not deteriorate appreciably in three or four days, when it may be bunched and trimmed to the proper length. By this treatment the market gluts occurring on account of Sundays and holidays, or hot waves, can be tided over with better prices and less waste.

Any prolonged holding of asparagus in cold storage is a problem not yet studied. It presents a different set of conditions from those of most other vegetables or fruits.

Fruits and most vegetables are matured storage organs of plants, and their structure and composition are adapted to preservation for a longer or shorter time. Asparagus, on the contrary, consists of the youngest stage of the plant at the period of most active growth. Its external and internal structures are adapted to rapid change in composition and development. The cell protoplasm persists in its activity at a reduced rate, while the delicate cuticle favors evaporation of the cell moisture and the attack of external molds. Hence, it is a difficult matter to arrest the changes and permanently hold the stalks in their pristine tenderness and flavor.

It is not usually desirable to hold asparagus more than a few days to prevent market gluts. The usual methods of keeping asparagus at summer temperatures cause rapid deterioration in quality, and should be remedied if a discriminating patronage is desired.

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Public Document No. 31

The Massachusetts Agricultural College

ANNUAL REPORT

OF THE

EXTENSION SERVICE

William D. Hurd, *Director*

For the Year ending November 30, 1916

Being Part V. of the Fifty-fourth Annual Report of the Massachusetts Agricultural College

Co-operative Extension Work in Agriculture and Home Economics, State of Massachusetts

The Massachusetts Agricultural College and the United States Department of Agriculture Co-operating

BOSTON
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1917

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THE MASSACHUSETTS AGRICULTURAL COLLEGE

ANNUAL REPORT

OF THE

EXTENSION SERVICE

WILLIAM D. HURD, *Director*

FOR THE YEAR ENDING NOVEMBER 30, 1916

BEING PART V. OF THE FIFTY-FOURTH ANNUAL REPORT OF THE MASSACHUSETTS AGRICULTURAL COLLEGE

Co-operative Extension Work in Agriculture and Home Economics, State of Massachusetts

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approved by the
Supervisor of Administration.

The Commonwealth of Massachusetts.

MASSACHUSETTS AGRICULTURAL COLLEGE,
AMHERST, Jan. 1, 1917.

To His Excellency SAMUEL W. McCALL.

SIR: — On behalf of the trustees of the Massachusetts Agricultural College I have the honor to transmit herewith, to Your Excellency and the Honorable Council, Part V. of the fifty-fourth annual report of the trustees, this being the annual report of the Extension Service for the year 1916.

I am, very respectfully, your obedient servant,

KENYON L. BUTTERFIELD,
President.

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ORGANIZATION FOR 1917.

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[1] Resigned.
[2] Co-operatively employed by college and United States Department of Agriculture.
[3] Deceased.

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[1] Resigned. [2] Transferred from Extension Service.

ANNUAL REPORT OF THE EXTENSION SERVICE

OF THE

MASSACHUSETTS AGRICULTURAL COLLEGE.

History and Organization.

Ever since the organization of the Massachusetts Agricultural College its staff of teachers and research workers have been called upon to do a great deal of extension work. The number of calls have multiplied greatly during the last fifteen or twenty years.

A definite plan for organizing the extension work of the college was begun Sept. 1, 1909, under an appropriation of the Legislature of that year which provided funds for the support of short courses.

The purpose of the Extension Service is to provide "instruction in improved methods of agricultural production and welfare of rural population . . . for the people not enrolled as regular students in educational institutions."

"It is a permanent system of practical education for farming people, outside of schools, conducted according to well-matured plans, by public officers for the benefit of all the people."

The work has been much in demand, and has grown rapidly. Recognizing the need, and in order to satisfy the demand, the State has increased the appropriations from time to time.

The Extension Service of the Massachusetts Agricultural College represents the whole institution — all departments and individuals — at work doing what it can to build up the industrial, and especially the rural, life of the Commonwealth.

Through the Extension Service an attempt is made to carry the teachings of the college, and the results of the research work of this and other stations and scientific laboratories, out to all the people of the State who may desire this instruction.

The methods of doing this are described in the reports from the several extension specialists, which may be found farther on in this report.

Every effort is made to co-ordinate the teaching, the research work and the extension work of the college so that they will all articulate and function together in developing and maintaining a well-defined institutional policy.

The type of organization which has been developed at this college conforms in the main to that recommended by the Association of Agricultural Colleges and Experiment Stations, the United States Department of Agriculture and prominent educators of this and other countries. Similar organizations are maintained in practically all of the other agricultural colleges and State universities, many of which, in fact, have patterned their extension divisions after our organization.

The extension work of this college has not been characterized by great expansion during the past year. The lack of additional funds has made the starting of new and much needed lines of work impossible. The work, however, has not been at a standstill nor gone backward. Advantage has been taken of the opportunity to "take stock" of lines of work already under way, and to organize our extension work in its relationships to the several departments of the college and to other agencies throughout the State on a better and more satisfactory basis than ever before. The extension specialists have studied their fields of work more thoroughly, have considered their work in its relation to a broad plan for rural development in the State more carefully, and have organized their work with greater attention to detail than in the past. This has all resulted in substantial progress toward developing a State-wide, unified and harmonious system of extension teaching in agricultural and rural life subjects for the Commonwealth.

Administration.

The administration of the extension work is vested in a director of the Extension Service, who is responsible directly to the president of the college.

For purposes of administration the Massachusetts Agricultural College is organized into the following main divisions: —

1. Academic work: (*a*) undergraduate instruction (with a dean in charge); (*b*) graduate work (with a director in charge).
2. Experiment station (with a director in charge).
3. Extension Service (with a director in charge).

These positions are co-ordinate, each officer being directly responsible to the president of the college.

A committee on Extension Service organization and policy of the Board of Trustees holds several meetings each year, and considers all plans for work, appropriations, etc. The action of this committee is submitted to the full Board of Trustees for ratification or modification.

The college cabinet, which is made up of certain of the administrative officers of the institution, usually passes on matters of general policy before these are submitted to the trustees.

The bulk of the extension work is carried on by extension specialists, who, by training, experience, disposition and other qualifications, are especially well fitted to do this type of teaching. In addition, every representative of the institution is expected to render to the people of the Commonwealth whatever service he may be able without impairing his ability to accomplish consistently good work in his own particular field.

Extension specialists covering general lines of work are responsible to the director of the Extension Service. In other lines, where the work is specialized and technical in character, the work is organized in the proper departments of the college, the extension specialists being responsible to the head of the department for the subject-matter taught, and to the director of the Extension Service for the organization and carrying out of his particular line of work. Frequent conferences between the head of the department, the extension specialist and the director afford opportunity for discussion of the work, laying of plans, etc. This type of organization avoids setting up separate staffs with consequent conflict and misunderstanding, and maintains a proper departmental unity throughout the institution.

Conferences of the entire Extension Service staff are held to discuss matters of general importance and interest.

All extension work is on a written project basis, agreed to by the department concerned and the director, and, in case out-

side organizations are involved, by these organizations and the college.

The director of the Extension Service acts as a joint representative of the United States Department of Agriculture and the college where Federal funds are used, or in co-operative projects between these two organizations.

Weekly reports of work done and that contemplated are made to the director by extension specialists. At the beginning of each fiscal year a detailed apportionment of funds is made for projects, and this must be approved by the trustees. All supplies, equipment, etc., are purchased on requisitions approved by the director and the treasurer of the college. Monthly reports on Extension Service funds are rendered by the treasurer of the college to the director. All bills, traveling expenses for approved trips, etc., are approved by the director before being paid by the treasurer. Accounts are checked by an auditor representing the trustees each month, and by the State Auditor's office twice yearly. Smith-Lever and United States Department of Agriculture Co-operative Demonstration funds are also audited by a representative of the United States Department of Agriculture after the close of each fiscal year.

Changes in the Staff.

Several changes in the extension staff have occurred during the past year.

Mr. R. H. Ferguson, specialist in co-operation and marketing, died Dec. 1, 1915. His place has been filled by the election of E. F. Damon, a graduate of this college in the class of 1910, who took up his duties Feb. 8, 1916.

The place made vacant by the resignation of George F. Story, as extension specialist in animal husbandry, has been filled by the election of W. F. Turner, a graduate of the Kansas Agricultural College in the class of 1910. He took up his work Dec. 12, 1915.

Mr. F. A. Cushing Smith was elected extension specialist in civic improvement to fill the place made vacant by the resignation of P. H. Elwood, Jr. Mr. Smith is a graduate of Cornell, and was until he came to us connected with the landscape gardening department of the University of Illinois. He took up his work Feb. 1, 1916.

Prof. O. A. Morton, in charge of boys' and girls' club work, resigned on July 1, 1916. Mr. George L. Farley, formerly superintendent of schools, has been secured to take his place, with the title of supervisor of junior extension work. Mr. Farley took charge Sept. 1, 1916.

Mr. Ralph W. Rees, extension specialist in pomology, resigned Aug. 1, 1916, to accept a position at Cornell University. Mr. Austin D. Kilham, a graduate of the Missouri College of Agriculture, was elected to this position and took up his work Aug. 20, 1916.

Mr. Eric N. Boland, agent in charge of pig club work in the junior Extension Service (co-operatively employed by the college and the United States Department of Agriculture), resigned to accept a position with the Quaker Oats Company of Boston. Mr. Victor A. Rice, a graduate of the North Carolina College of Agriculture in 1916, has been secured to fill this place, and will take up the work Dec. 4, 1916.

Mr. Benjamin W. Ellis, assistant State leader of county agent work, resigned in December, 1915. Mr. Sumner R. Parker, a graduate of this college in the class of 1904, and until coming to us county agent in Franklin County, Mass., was elected to this position. The appointment took effect Dec. 10, 1915.

Prof. E. D. Waid, for the past five years assistant director, has tendered his resignation, to take effect at a date yet to be determined. His successor has not as yet been selected.

Miss Laura Comstock has been made leader of home demonstration work for women (in charge of women county agents).

Miss Mabel Case, first clerk of the Extension Service, resigned, to take effect Jan. 14, 1916. Mr. Elbert L. Arnold was secured to fill the place, with the title of chief clerk of the Extension Service.

Miss Hannah Griffin, Miss Elsa Slattery and Miss Phyllis Cogswell, clerk and stenographers, resigned during the year. Miss Flora Torrey, Miss Doris Clark, Miss Marion Pomeroy, Miss Ethelyn Streeter, Miss Ethel Kennedy and Miss Hazel Dewar have been secured to fill these places and as additional help.

Finances.

Support for extension work in Massachusetts is derived from the following sources, and for the past year in the following amounts. (Money expended for short courses is not included in this report of extension work.)

1. State funds (expended by the college): — Apportionment Dec. 1, 1915, to Nov. 30, 1916,		$43,032 59
2. Smith-Lever funds (expended by college co-operating with United States Department of Agriculture): — Act of Congress, May 8, 1914,		12,930 75
3. United States Department of Agriculture Co-operative Demonstration funds (for work outside the Cotton Belt); expended by college in farm bureau and other co-operative work): — Amount assigned to Massachusetts this year,		17,026 00
4. Funds raised by county organizations for support of farm bureau work (expended by farm bureaus) (chapter 707, Acts of Legislature, 1914): —		
(*a*) Funds appropriated by counties,	$37,200 00	
(*b*) Funds raised from other sources,	28,900 00	
		66,100 00
Total,		$139,089 34

The funds appropriated by the State are unrestricted, being given for general extension work.

The Smith-Lever funds are subject to the limitations of that act.

The United States Department of Agriculture Co-operative Demonstration funds are appropriated directly to the United States Department of Agriculture, and are assigned to the States as the department sees fit.

The funds appropriated by the several counties for farm bureau work are authorized by an act of the Legislature (chapter 707, Acts of 1914). Any county may appropriate through its county commissioners such sums as it deems wise, providing the amount does not exceed that raised from all other sources. These funds are spent by the county organizations, and do not come to the college.

Some Prominent Features of the Work during 1916.

Several significant things connected with the work suggest themselves as being worthy of special mention.

1. *County Agent Work.* — The year has been one of marked progress in the organization of farm bureaus. Three new organizations have been started. None have failed. Middlesex, Dukes and Nantucket are the only counties not organized. The first of these will incorporate an organization on December 16. The work in the farm bureaus has been placed on a written project basis, relationships are more clearly defined, farm bureau officers have a better idea of the purpose of their bureaus, and the county agents know their field better and are restricting their efforts to fewer lines of work. A significant thing has been the growth of work for women in four counties. Two other counties are to place agents in the field soon.

2. *Junior Extension Work.* — The boys' and girls' club work continues to be our largest and perhaps most popular activity. The development of junior extension work under the direction of Mr. Farley, will, I believe, far surpass any of the work done in the past, although the enrollment may not be so large as in previous years.

There is need of securing more funds to help maintain supervisors, for adequate follow-up work is in our judgment the thing most needed at present.

3. *Rural Organization.* — Much progress has been made in organized movements in agriculture in the Commonwealth during the past year. Thirteen new co-operative organizations for buying and selling have been brought into existence. Thirty are now in successful operation. College men and county agents have been leaders in the movement to organize the milk producers. Our publication on "The Cost of Milk Production" and the advance copy of "The Cost of Milk Distribution" have been taken as the authority on which to discuss the situation by all parties concerned. Especial mention should be made here of the great piece of work which has been done by the county agents in organizing the milk producers of the State, and in bringing about a better adjustment of the dairy situation during the past few weeks.

4. *Local Community Organization.* — The work of local community planning has been somewhat interfered with during the year by other lines of work which have been assigned to Mr. Morgan. He has acted as secretary of the Massachusetts Federation for Rural Progress, and has spent a good deal of his time in work for the Massachusetts Development Commission. His work with these organizations has prevented him doing the follow-up work which we consider so essential to successful work in this particular line.

5. *Finances.* — I feel that notwithstanding that we have had so many calls for more work, the fact that we came through the year and had a balance of $2,572.75, in addition to the reserve and emergency fund, is worth mentioning.

6. *University Extension for the Connecticut Valley.* — During the year this college has joined with Amherst, Smith, Mount Holyoke, the International Y. M. C. A. College, and the Northfield institutions in a co-operative movement to offer university extension work to the people of the Connecticut Valley and adjacent towns. This is in accordance with plans suggested by the University Council of Massachusetts for State-wide extension work. A large and comprehensive announcement has been distributed. The university extension department of the State Board of Education has assigned an agent to organize the work. His headquarters are at this college.

7. *Relationships with the United States Department of Agriculture.* — Our relationships to the United States Department of Agriculture have been most friendly and satisfactory. The work which they have desired to do has generally been carried on in accordance with the general memorandum of understanding, and minor difficulties have been quite easily adjusted.

8. *National Dairy Show.* — The coming of the National Dairy Show to Springfield seemed to place a peculiar obligation on this college. Ten or more members of our faculty spent a large amount of time in helping to make the show a success. I estimate that we expended between $2,000 and $3,000 in time and money in this connection.

9. *Publications.* — Considerable printed matter in the shape of bulletins, circulars, leaflets, etc., has been prepared and printed during the year. A committee on publications was

created in the college to have supervision over the preparation and printing of all college publications, and is proving to be a useful and effective agency in helping to develop a higher standard in our printed matter. Many bulletins formerly printed by the experiment station have now been turned over to the Extension Service for publication.

The operations of this committee, the kind and number of our publications, methods of distribution, etc., are described in the report on printing and publications later on in this report.

10. *Gifts.* — The most important donation to the Extension Service during the year was the providing of an annual fund of $1,000 by four of the leading meat-packing firms doing business in this State, to be used as prize money in boys' and girls' pig clubs. The firms which contributed this fund are North Packing and Provision Company, Boston; J. P. Squire Company, Boston; Springfield Provision Company, Brightwood; White, Pevey & Dexter Company, Worcester.

11. *Co-operation with Other Agencies.* — It is an established conviction of the Massachusetts Agricultural College that it is only through co-operation and correlation of the work of the several agencies interested in rural development that the greatest progress can be made. To attain this end the Extension Service has always endeavored to work with and through all other agencies so far as has been possible.

During the year the Extension Service has worked with and received assistance from the following organizations: United States Department of Agriculture, State Board of Agriculture, State Board of Education, State Forester, Massachusetts Highway Commission, Free Public Library Commission, Dairy Bureau, Bureau of Animal Industry, State Department of Health, State Board of Charities, Homestead Commission, all of the farm bureaus and improvement leagues, Massachusetts Civic League, Massachusetts Federation of Churches, county work departments of the Young Men's and Young Women's Christian Associations, agricultural committees of chambers of commerce in several cities, Massachusetts Fruit Growers' Association, Massachusetts Poultry Association, Massachusetts Dairymen's Association, Massachusetts Milk Inspectors' Association, Massa-

chusetts Sheep Breeders' Association, Massachusetts Swine Breeders' Association, Eastern States Agricultural and Industrial Exposition, National Dairy Show, New England Federation for Rural Progress, Massachusetts Federation for Rural Progress, Massachusetts Development Commission, Massachusetts State Grange, many Pomona and subordinate granges, American Home Economics Association, New England Home Economics Association, school authorities, Massachusetts Anti-Tuberculosis League, Society for the Prevention of Cruelty to Children, Simmons College, Boston School of Eugenics, and twenty-two of the State institutions, such as hospitals, asylums, prisons, etc.

Additional Offices, Equipment, etc.

During the year four additional offices have been made available for members of the staff who have their headquarters in connection with the general office. The necessary office equipment has also been provided, including intercommunicating telephones.

Various charts, photographs, several sets of lantern slides, new exhibit material to be used at fairs and other meetings have been added. Motion-picture apparatus has not been purchased because of the stringency of Massachusetts laws governing the use of this equipment, it being practically out of the question to make general use of the motion picture as an educational factor in the smaller towns of the State under the exacting regulations.

INDIVIDUAL REPORTS OF EXTENSION WORKERS.

REPORT ON EXTENSION WORK IN HOME ECONOMICS.

The following lines of work in home economics subjects have been carried on during the year.

Lecture Demonstrations.

Ninety-three lecture demonstrations have been given. The following organizations co-operated with the college in arranging these meetings: granges, schools (day and evening classes), parent-teacher associations, mothers' clubs, working girls' clubs, preparedness society, farmers' clubs, teachers' clubs, Eastern Art Teachers' Association, camp fire groups, Short Course Club Women, and New England Home Economics Association. Subjects discussed were: (1) meaning and scope of home economics; (2) Federal and State government aids; (3) foods; (4) kitchen planning; (5) budgets; (6) work of women of community; and (7) school lunches. Some of the results of these meetings are shown by the addition of home economics books and the "Journal of Home Economics" to home and public libraries, equipment added to kitchens, rearrangement of kitchens, and the establishment of the hot lunch system for school children in several instances.

Demonstrations.

Thirty-two demonstrations were given during the past year, aside from the ten in extension schools. Six demonstrations were given on meat substitutes, dairy products and the hot school lunch. A talk on home care of the sick was given at a field day meeting, and a demonstration of the right method of making a bed for a patient.

National Dairy Show and Eastern States Exposition.

The home economics work presented at the National Dairy Show held in Springfield, October 12 to 21, was under the direction of the home economics workers of the Extension Service. This work began with the construction of plans for

the home economics room in the Eastern States Building. Equipment for this room was selected by the home economics workers, and the program for six days of the exposition was also arranged.

The program for each of the six days consisted of two-hour demonstrations of dairy products. The home economics workers of New England and New York were asked to co-operate by submitting tested milk recipes and giving demonstrations. These submitted recipes were compiled into a cook book, an introduction being written on the food value of milk. These booklets were distributed during the exposition.

The room was open to visitors during eight hours of each day. Information was given concerning food for the family, special diets, equipment, reference books and bulletins, charts and other related matter.

In addition to the adult work, assistance was given in the junior division. This work was as follows: instructing the bread demonstration team, being done jointly with the Worcester County Home Economics agent; judging the work of the judging teams sent from the different States; judging the bread offered in the prize competition.

Committee Work.

As chairman of the extension committee of the New England Home Economics Association, the State leader assisted in forming county branches in Berkshire and Worcester counties. The members of these organizations plan to discuss subjects relating particularly to their own schools, and to furthering the work of boys' and girls' clubs. One meeting was held in Holyoke, in co-operation with the Public Health Nursing Association, to which all home economics teachers of Hampden, Hampshire and Franklin counties were invited.

The State leader, as chairman of a committee of the American Home Economics Association, procured home economics literature from each State in the Union and Canada for Dr. Langworthy of the United States Department of Agriculture. This literature is to be examined in the hope that the Federal government may reprint certain bulletins, thereby making practical publications available to all States.

As a member of the health and sanitation committee of the college the State leader gave assistance in securing a manager and dietitian for the dining hall on the campus.

Under the chairmanship of the State leader the annual session of the New England Home Economics Extension workers prepared score cards for bread and canned fruits and vegetables for general use throughout New England. It was also voted that emphasis should be laid upon suitable lunches for school children by the extension workers.

Publications.

In addition to the bulletins for farm women, previously written and issued by the Extension Service, two more have been prepared during the past year entitled "Our Daily Food and Some Factors in Meal Planning," as well as a list of books for farm women, prepared in collaboration with the college librarian. A leaflet concerning the work of women county agents, its purpose and maintenance, was prepared for distribution in Middlesex County.

Correspondence Course.

A correspondence course of ten lessons on nutrition has been offered this past year. Printed lesson sheets, Kinne & Cooley's "Foods and Household Management" and government bulletins form the text. Practical as well as theoretical work is required. Papers of students are corrected at the college.

The group method of study was urged, with the result that Assonet, Everett, Gardner, Reading and Shelburne each formed such a group. The State workers visited these groups, giving talks and demonstrations and conducting round tables.

Statistics for the home economics correspondence course are included in the report of the supervisor of correspondence courses. It might be well to say here, however, that there was a total registration of 56 in the 6-group study classes, and there were 59 individual students at work during the year, making a total of 115 students who were at work upon this course during the year.

Junior Extension Work in Home Economics.

In connection with the home economics clubs for girls, an effort has been made to secure at least one woman in a community to act as leader, and a definite program has been suggested for the year's work. The home economics club work of one group was judged, children and parents addressed, and local prizes awarded to the girls who had done the best work in bread making and in sewing. Two canning demonstrations were given under the auspices of a town club leader before two of his clubs. Junior exhibits were held with four leaders of girls' clubs, and advice given as to the year's work. Outlines in sewing and cookery were given to four rural schools; conferences with three of these teachers have been held and plans carefully made for the year's work.

Co-operating Agencies.

During the past year, as never before, the extension workers have been able to co-operate with individuals and other organizations in the State. The work has been strengthened thereby in three ways, — first, by avoiding duplication of effort; second, by creating a right interest in home economics; third, by acquainting these organizations and individuals with the aims of the work. Following is a list of the co-operating agencies: "Springfield Republican," Parent-Teacher Association, Massachusetts Development Commission, Public Health Nursing Association, Massachusetts State Board of Charities, Society for the Prevention of Cruelty to Children, Massachusetts Anti-Tuberculosis League, School of Eugenics, Massachusetts Branch of the Preparedness Society, Barnstable County Community Conference, New England Home Economics Association, National Young Women's Christian Association and individual women. Special mention should be made of five of these agencies.

Two lectures and one demonstration were given during the good homes week at Springfield, held under the auspices of the "Springfield Republican."

Through the Northampton agent of the State Board of Charities four families were visited and reported.

Dr. Evangeline W. Young of the School of Eugenics, Boston, agreed to co-operate with the college in lecturing once each week, from Oct. 1, 1916, to Dec. 31, 1916, in any part of Massachusetts on any aspect of public or personal health. Eight meetings were arranged. In September Dr. Young gave two lectures at the canning and home economics school held at Essex County Agricultural School, and planned a course in physiology to be given to the girls of that school, and also agreed to give the sex hygiene lectures.

A request was received to recommend a person as recreation and health leader in a rural community during the summer. Such a person was secured and plans made for the work. A report of this enterprise is on file at the college. Conferences were held with a girls' club leader of another town as to work and methods for the club.

Grange.

During the past year fifteen invitations to speak and demonstrate before subordinate granges were accepted.

All-day meetings, organized by the lecturer of the State Grange, were held during one week in November. Nine lectures were given on household management and the value of regular study of home problems; three demonstrations on milk and eggs were given. It is expected that these meetings will be followed by the organization of groups to study problems of the home as they relate to the work of each day of the week. To accomplish this one woman from each of the six towns visited was appointed to serve on the home committee. This committee is to meet at the annual meeting of the State Grange in December. At this meeting study outlines and reference books, methods of carrying on work and suitable speakers are to be suggested by the college representative. Members of the home committee are to organize and supervise the work of the study groups in their respective towns. The extension workers will meet occasionally with these groups.

Extension Schools.

Homemaking work has been offered as usual in connection with the ten agricultural extension schools. It was the aim of the work to create an increased interest in homemaking, to

establish right food habits, to better methods of housework, to raise standards of sanitation, to establish closer relations between the home and community and to convince women of the value of the home. Sixteen one-hour lecture demonstrations and five two-hour food demonstrations were given at each school. They were classified as follows: food, health, the home and the community. The audiences were composed mainly of housekeepers. In seven towns school children were present during part or all of the sessions. It was reported by three teachers that the girls were as interested in the lectures as in the food demonstrations.

Outlines were given out for each lecture and demonstration. A questionnaire was filled out by those registered, relative to the social life in the home, its sanitation, and labor-saving appliances. The outlines and questionnaire for 1916–17 were revised. For this winter plans have been made to secure the promise of those who attend the schools to follow up certain suggestions listed.

Loan libraries of ten or twelve volumes were taken to each school. These books were referred to through the week, and were left at the local library for eight weeks or longer if request for extension of time was made. As a result some books were added to homes in nine towns, to public libraries in five towns and to a church library. In four towns plans for study were made. There were ten groups formed. They carried on work through the winter and spring, following the outlines given them at the schools. Both extension workers met with each of these groups, giving lecture demonstrations or food demonstrations.

Questionnaires received from the extension schools of 1914–15 were returned to those who filled them out, and they were asked to note changes which had been made in their homes due to instruction given in the schools.

Location and Attendance.

Work in homemaking was included in the schools held in the following places: Pepperell, Prescott, North Attleborough, Barre, Westford, Cummington, Grafton, Chesterfield, Northfield and New Bedford. The total attendance at all of these

schools was 2,626, or an average attendance per school of 263. The average daily attendance was 52, ranging from 19 to 81 in the different schools.

In addition to the regular homemaking sections in connection with the agricultural schools, two special schools were conducted and certain work offered in community planning during the winter. This work is outlined below.

A canning and home economics school was held at the Essex County Agricultural school the first week in September. The program was planned by the college, and speakers and demonstrators were secured to carry on the work. The agencies co-operating with the County Agricultural School and the college were the United States Department of Agriculture, the Massachusetts State Department of Health, Boston School of Eugenics and Simmons College, Boston.

The school held two sessions each day for five days. The membership of the school was composed of housekeepers and prospective club leaders. The mornings were given to lectures on growth and production of fruits and vegetables, and to the canning of these products. One morning jelly and marmalade were demonstrated. The afternoons were given to discussions on well-planned menus, sanitation, personal hygiene, public health and junior club work. The average daily attendance was 39 and the total attendance was 399. The total number of canned products put up by the class was 195.

Schools in Community Planning. — Two one-hour demonstration lectures were given in each of the two schools held at Sutton and Westminster. A substitute had to be provided for the Sutton School. In the morning labor-saving appliances were discussed, local merchants loaning illustrative material. In the afternoon the subject of women's part in the work of the community was considered. The importance of proper food for school children was emphasized.

School in Sewing. — Three evenings were given to a group of girls to teach them the cutting, fitting and making of shirt waists. Each girl made a waist for herself.

County Agents.

Great interest has developed this year in the work of women county agents. Prior to 1915 Hampden County was the only one organized for home economics work. Since July of the present year Worcester, Franklin and Barnstable counties have employed women agents. Conferences and mass meetings were held previous to their appointment to arouse interest and insure support. Candidates were chosen with the approval of the home economics committees, farm bureau secretaries and the college. Since these county agents have taken up their duties the State leader has attended council meetings held to strengthen the women's county organizations.

Meetings and conferences have been held in Norfolk County, and it is expected that a county agent will soon be secured. This will be the first county to have a home demonstration agent in connection with a county agricultural school. Middlesex County has held meetings to present the matter of a farm bureau organization, which will employ a home economics agent. One other county is contemplating the first step in organizing home economics work on a county basis.

During the spring a two weeks' program was presented in one of the counties which maintains no home economics agent. Canning demonstrations and lectures on foods, club projects and women's work in the community were given during this period.

Needs.

Frequent visits to rural communities have shown the very great need of instruction in matters of health and sanitation in the farm homes. Without doubt one of the most pressing demands of the extension work is for another member of the staff specially trained in nursing, hygiene and sanitation. Such a worker would be of untold value to the rural districts which are not reached by other public health agencies. If this worker were capable of giving instruction in public recreation it would be a most desirable asset.

The addition, also, of one person to assist in the extension school work would give the remainder of the staff an oppor-

tunity to carry on certain important phases of the work which must, under present conditions, be either slighted or wholly neglected.

STATISTICS.

	Number.		Attendance.	
Lecture demonstrations: —				
Foods,	29		958	
Community work,	8		408	
School lunch,	7		195	
Hygiene and health,	13		627	
Miscellaneous,	36		3,438	
Totals,		93		5,626
Conferences,		60		1,006
Demonstrations: —				
Canning,	32		1,355	
Foods,	6		381	
Miscellaneous,	5		186	
Totals,		43		1,922
Extension schools: —				
Homemaking,	10		2,626	
Canning and home economics,	1		399	
Sewing,	1		32	
School in community planning,	1		114	
Totals,		13		3,171
Correspondence course: —				
County home demonstration agents,		3		-
Totals,		212		11,725

REPORT ON COUNTY AGENT EXTENSION WORK.

The rapid development of farm bureau work in Massachusetts during the last two years has called for a great deal of careful organization. Problems of relationships and administration have been difficult and perplexing. The urgent demand of the people for the type of work offered, and the sincerity and enthusiasm of those engaged in the work, have surmounted most of these difficulties, and have given to the State what now seems to be a definite, thorough and efficient type of organization for carrying on extension work in agriculture and home economics.

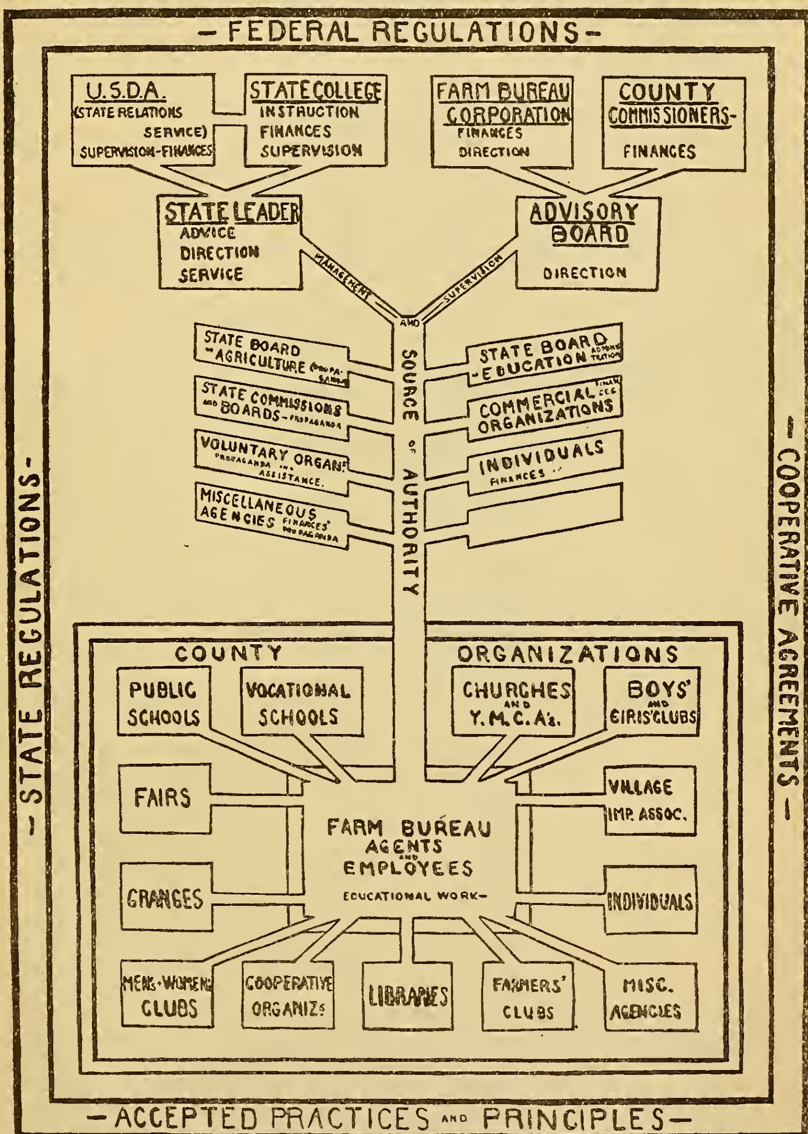
ORGANIZATION.

In order to supply the funds appropriated from Federal and State sources to extension work in counties in a definite and effective way, farm bureaus and county leagues were organized.

Each county organization in this State has been incorporated. The law authorizing their incorporation is chapter 707 of the Acts of 1914. This act provided that an organization in any county, formed for the purpose of the improvement of agriculture and country life, approved by the Massachusetts Agricultural College and the county commissioners, might receive funds from the county treasury for the support of this work. These county organizations bear three names, — county farm bureaus, county improvement leagues and county agricultural schools. The county agricultural schools support county agent work through their farm bureau departments, and this division exactly parallels the farm bureau of other counties, with the exception that local funds are supplied through the trustees of the school.

The relationships between the people in the county, the county organization, the State college and the United States Department of Agriculture have been carefully worked out, and are now quite definitely established in the minds of the county workers and the people of the State. The following chart serves to illustrate graphically the relationships as they exist at present: —

RELATIONSHIPS IN COUNTY-AGENT-WORK



Sample Project.

Copy.

Project Number.
F. C. D. N. & W.: ....
State Ext. Div.: ....

County Agent Project.

Extension Work in Agriculture and Home Economics
in............County, Massachusetts,
The............County Farm Bureau,
The Massachusetts Agricultural College,
and the United States Department of Agriculture,
Co-operating.

Name of Project:	Demonstrations by means of a County Agricultural Agent.
Leader:	....
Location:	....................County, Massachusetts.
Headquarters:	....................Massachusetts.
Date Effective:	January 1, 1916.
Legal Authority:	State Legislation granting funds for Extension Work to the Massachusetts Agricultural College.
	Acts of Congress, May 8, 1914 (Smith-Lever Bill), to promote Demonstration Work in Agriculture and Home Economics.
	Acts of Congress (H. R. 13679) "For Farmers' Co-operative Demonstration Work Outside of the Cotton Belt."
	State legislation (chapter 707), Acts of 1914, "An Act to authorize counties to aid corporations organized to promote agriculture and country life."
Object:	To conduct demonstrations for the purpose of improving the agriculture of..................County.
Method of Procedure:	Residents of the county will be met individually or in groups for the purpose of teaching and demonstrating better agricultural practices, the benefits to be derived from co-operative efforts, better methods of marketing farm products, and the organization of communities to build up the social life.
	The Agent or Agents will attempt to organize the different agencies within the county so that each shall contribute the largest possible amount of service to the building up of the rural life of the county, and will also bring to the county all possible helps which can be secured from outside agencies which may be able to assist in this work.
	The Agent or Agents coming under this co-operative agreement shall be considered as local representatives of the Massachusetts Agricultural College and the United States Department of Agriculture. Extension work in the county will be organized with and through the Farm Bureau as a center, and it is expected that all outside agencies and individuals, so far as they can be controlled, will recognize the Farm Bureau as the local agency through which all extension work shall be organized.

METHOD OF PROCEDURE — *Concluded.*

Projects covering the principal lines of work to be carried on within the county are to be prepared by the agent and submitted for the joint approval of the Advisory Board and the State Leader before these projects are put into operation.

Regular meetings of the Advisory Board and State Leader are to be held for the purpose of hearing reports of the Agents and to consider matters pertaining to the administration of the work.

Weekly and other necessary reports are to be rendered in duplicate, one being filed in the office of the Farm Bureau and the other sent to the office of the State Leader.

It is expected that the Agent will attend such conferences as are arranged for the benefit of the work.

ORGANIZATION:

The organization of this work shall be vested in a County Agent or Agents who shall work under the joint direction of the Advisory Board, representing the Farm Bureau organization, and the State Leader, co-operatively employed by the Massachusetts Agricultural College and the United States Department of Agriculture.

The persons employed jointly by the Massachusetts Agricultural College and the United States Department of Agriculture as County Agent of the......... County Farm Bureau shall be approved by the Advisory Board and the State Leader before actually being engaged.

OPERATION:

This project comes under State Project Agreement No. 2 between the Extension Service of the Massachusetts Agricultural College and the United States Department of Agriculture, covering County Agent work in Massachusetts.

FINANCIAL SUPPORT:

It is understood by the parties to this Project Agreement that each shall contribute annually to support the work the cash sums, the supplies and the services indicated by the following schedule: —

Co-operating Parties.	Cash Contributions.		Other Contributions.
	Salary.	Expense.	
.... County Farm Bureau,			
County Funds (yet to be secured under law) estimate.			
Massachusetts Agricultural College,			Assistance of entire Extension Service staff. Supervision, publications and other helps.
United States Department of Agriculture.			

HISTORY:

Date:..

President,.............County Farm Bureau.

Date:..

County Agent Leader, County Agent Work, U. S. D. A.

Date:..

Director of Extension Service.

Date:..

President, Massachusetts Agricultural College.

In order to more thoroughly define and specify these relationships a co-operative agreement has been entered into with each farm bureau which covers the following points: the way in which agents shall carry on the work, relations to agencies within and without the county, the representative character of the work and the way in which supervision, funds and assistance shall be supplied.

HISTORY.

It may be well to review the development of county agent work in the State in order to give a better understanding of the present situation. Early in 1913 the Hampden County Improvement League started work with three men. It was the first organization of its kind in this State, and as such had to do a great deal of pioneer work. It created State-wide interest and enthusiasm for county agent work. It has been steadily growing and enlarging the scope of its influence. In 1914 several other counties became interested, and farm bureaus were established in Worcester, Franklin, Hampshire, Plymouth and Norfolk counties. A county agent was appointed in Bristol County in connection with the Bristol County Agricultural School. While these organizations were started in 1914 many of them did not secure their agents until the following season.

The work during the year 1914 was largely that of organizing and getting acquainted with the people in the county, and gathering preliminary information necessary for the successful carrying on of the work.

During 1915 the Berkshire County Farm Improvement League was organized, and Barnstable County appointed a county agent in connection with the Faunce Demonstration Farm.

In 1916 the Cape Cod Farm Bureau was incorporated, and for the first time a county-wide organization began work. In Berkshire County a county agent was employed who began his duties the 1st of May. In Norfolk County the farm bureau was taken over by the Norfolk County Agricultural School the 1st of March, and since that time has been continued as the extension department of that school, the same county agent being retained and the funds and support for the work coming entirely from taxation sources in appropriations for the school.

In Bristol County the advisory committee of the county agricultural school was enlarged to form a farm bureau department to support the work of the county agent. This, through a system of town committees, more nearly duplicated the farm bureau organizations in other counties. In Essex County a farm bureau department was established in connection with the Essex County Agricultural School, and a county agent employed to take charge of the work.

In Middlesex County a farm bureau was formed during the latter part of the year, and is just getting under way. These various organizations are now employing on full time 19 men and 6 women. Of these, 12 men and 4 women are co-operatively employed by the county organization, the Massachusetts Agricultural College and the United States Department of Agriculture.

Funds.

The funds for county agent work come from several sources. First, membership fees. Every farm bureau, aside from the county schools, has an individual membership fee of $1. This brings in on an average of about $650 to $700. Second, contributions are solicited from individuals and organizations, such as business firms, banks, manufacturing establishments, boards of trade and granges. In some counties this has amounted to quite a sum. Third, town appropriations. These may be granted according to the law under which the farm bureau is established, which allows towns to appropriate funds for demonstration work in the town for the benefit of agriculture, and provides an increasing source of funds for farm

bureaus. Fourth, county funds. In most of the counties in this State half the budget of the farm bureau is appropriated from county funds. Fifth, the Massachusetts Agricultural College and the United States Department of Agriculture together contribute $1,200 a year toward the salary of the county agent, and an additional sum of $300 is provided where a home demonstration agent is maintained.

Members.

A very good measure of the effectiveness of county agent work and of the interest of the people of the county in their organization is considered to be the membership of the farm bureau. A large membership is highly desirable, especially to an agent beginning work, as it assures him of a group of people disposed to welcome the work at the start. The membership of the farm bureaus in this State has grown during the past year from an average of about 450 to an average of about 654 in the seven counties which have farm bureaus with individual membership.

Projects.

Each person at work in the farm bureau during the past year prepared a careful outline of his or her proposed activities in order that the work might be done in a definite and careful way. These outlines of work were presented to the advisory boards and signed by their chairmen. They were also presented to the Extension Service of the college, and were signed by the director of extension. This not only guarded against hasty action by the county men, but it gave a joint responsibility for the work to all parties concerned. It also gave each county agent a definite line of work to present to his members. The following data constitute a partial summary of the annual reports of the county agents in the State, and, due to the co-operative nature of the work, these several projects are also reported upon by the several extension specialists from the standpoint of their work in connection with the several projects.

Apple-spraying Campaign.

One of the important pieces of work undertaken last year was termed a State-wide apple-spraying campaign. All of the agents took a part in this work, and the results were quite satisfactory. Special lectures were given in each county on this subject, a new spray calendar was issued by the pomology department of the college, and a special system of records was devised in order that the cost, the increase in the amount of fruit and profit per tree be found in order to tell the average farmer the amount of profit he might expect to receive for his investment in spraying. It will be readily seen that it was quite difficult to locate unsprayed trees in the orchards of those growers who were already convinced of the value of spraying. It will also be seen that it was necessary to get check trees on the farms of most of those men who were less successful in their orchard practice. The county agents gave between 55 and 60 public demonstrations to show the farmers the necessity of thorough work, proper equipment and material to use. These were given in various parts of the State. The records secured in no way approach experiment station data in degree of accuracy, but they do represent the actual cost to farmers in doing on their own farms an operation that is a common farm practice. A statement of the figures secured will be found on page 70 in the report of the specialist in pomology. From the data secured it may be seen that a man who has an orchard of fair-sized trees and does not spray can figure that it will cost him about 50 cents per tree, and he may expect about $1\frac{1}{3}$ barrels increase, and with the prevailing price of apples at this year's level the increased value of the fruit would be about $4.50 per tree. This piece of work has demonstrated to those in county agent work that there is a big advantage in all working together toward a definite end, as the information obtained is much more convincing than that secured from a single county. It has also been a great help in making a good farm practice common practice.

Junior Extension Work.

The second important line of work taken up was the junior extension club work. This work has been developing very rapidly, and has required a great deal of time in organization. The part of the county agent has been to interest the people in the various towns in this work, secure local supervision, and see that the work begun by the children was carried through to a successful finish. The work done along this line has been very satisfactory. During the fall of 1916 the exhibit of boys' and girls' club work at the Eastern States Exposition required a large amount of time and effort on the part of the county agents. A special feature of the boys' and girls' club work has been a stimulating of interest in local fairs, and at these county agents have been requested to judge products. As this work becomes better organized it should require less time from county men.

Soil Acidity and Lime.

A great deal of work has been done for the improvement of soil conditions both in regard to soil acidity and the purchase of commercial fertilizers. The county agents reported the testing of soil for acidity on 144 farms. Demonstrations to show the value of lime for the growing of clovers have been carried on in every county. The importance of the use of lime, however, has required very little demonstration work, and the efforts have been made to secure for the farmers a satisfactory scheme of purchase. Groups of farmers have been induced to buy car lots of lime. In this way they greatly reduced the cost of handling. While it is difficult to secure accurate figures as to the increase in the use of lime in Massachusetts, we know from the output of the lime companies that this increase amounts to hundreds of cars every year, one county alone reporting 200 cars.

Alfalfa.

A great deal of interest has been manifested in growing alfalfa, and the acreage of this crop is rapidly increasing. The county agents report 59 demonstrations covering 71½ acres being carried on to show the proper methods of seeding and

harvesting, and to show that the crop can be grown economically. Other crop demonstrations have been carried on for the improvement of corn, potatoes, hay, soy beans, etc.

Dairying.

Dairying comprises the largest part of the farm business of the State, and for the last few months the work of the county agents has been to assist this industry. Dairymen have been assisted in forming local organizations in order that they might better the conditions of production and sale on their farms. Nineteen such locals have been formed in four counties. It is work of this sort that the farmers have most appreciated, as it would have been necessary for many farmers to abandon milk production under recent readjustment of values unless such assistance had been rendered. Dairy farmers have also been assisted in securing better cows. Forty pure-bred bulls have been purchased at the suggestion of the agents. An exhibit of dairy cows at the fairs was carried on to demonstrate the necessity of careful individual records on each cow, in order to effect improvement by breeding and feeding. Efforts will be made this year to carry this work further, and to render all assistance possible to this industry.

Farm Records and Business Organizations.

In order to properly answer questions relating to farm business, county agents have taken 105 farm records. They have assisted 221 farmers to start and keep a proper system of farm accounts. Considerable opportunity has developed for the co-operative purchase of farm requirements and the co-operative sale of farm products. Twelve organizations have been formed for the purpose of conducting such business in counties where agents are located. In one county a group of farmers was interested in purchasing better seed potatoes, and sent their agent with one of their number to the seed potato section in Maine to secure good stock. They purchased in this manner 1,370 bushels. It is work of this type by the county agents that farmers most appreciate.

A great deal of miscellaneous work has been taken up by the county agents including exhibits at local and county agricultural society fairs, laying out drainage systems, arranging crop rotations and assisting farmers in disposing of miscellaneous farm crops.

The work of the county agent leader has comprised mostly administrative work, such as attending meetings of executive committees, securing of candidates for employment on county work, making and classifying of reports and assisting new counties to organize. With the organization of the Middlesex County Farm Bureau the last large agricultural county in the State will have taken up the work, comprising about 98 per cent. of the available area in the State. It is felt that the work is rapidly finding a distinct and valuable place in the agricultural development of the State, and it is to be hoped that the work may be continued on some lines of agricultural development, and be of real assistance to the agriculture and country life of the State.

REPORT ON JUNIOR EXTENSION CLUB WORK.

Junior extension work as it is developing in this State is dividing itself along two lines: (1) home and school garden work, where cities and towns are interesting large numbers of children in the cultivation of small areas; (2) club work, where, in smaller groups, boys and girls are being interested in eight different projects, — market gardening, corn growing, potato growing, poultry keeping, pig raising, home economics and canning and marketing.

In our cities the aims of the work are to turn waste spaces and back yards into beauty spots and sources of income, and to interest those boys and girls who have a natural tendency toward agriculture, thus aiding them in the correct choice of a vocation.

In rural communities the aim is to make the life of children more interesting and enjoyable, that a larger number may be content to stay in the country and help build up rural life.

The conditions under which large numbers of our children are growing up, the absolute lack in their young lives of cer-

tain fundamental training which is absolutely necessary to later success, emphasize the vital need of something which will supply such training. We believe that club work fills this need, and the whole-hearted spontaneous response of the young people, as thus far organized, is proof of its true worth. As long as the work contains an element of play, and just enough of the technical to enable the young people to get results and realize some financial returns, they will find pleasure and profit in doing it.

Effort should be made to interest children to continue this work for over a series of years. They should not only learn to produce economically, but in most of the projects should be trained to find ways of disposing of their products, thus learning the fundamental principles of marketing.

Projects.

General Statement. — Any boy or girl in the State of Massachusetts between the ages of ten and eighteen was eligible to enroll in one or more of the projects mentioned below. The reports required varied in the different clubs, but every member was expected to write a story of experience in order to complete the work.

Market Gardening. — Club members who enroll in this project must have a garden of not less than one-twentieth of an acre. It is usually limited to one, or, at most, to a few vegetables. They are required to keep in an account book all items of expense, such as fertilizer, labor, etc., and the amount of produce sold. We feel that the results of the work in this club are very much worth while. Enrollment for 1916, 1,361.

Corn and Potato Growing. — While these clubs are small the members who enroll seem to show a great deal of interest and the results have been satisfactory. They differ from the garden clubs in that they embody the idea of production under field rather than garden conditions. Enrollment for 1916: corn, 172; potato, 504.

Poultry Keeping. — The poultry club has proved to be one of the most popular clubs, and a great deal of enthusiasm and competition has been shown in this contest. Thus far the work

of this club has consisted of egg production only. The members are required to have not less than 6 or more than 100 pullets or hens. The contest runs for four months, opening March 1 and closing June 30. Enrollment for 1916, 1,033.

Pig Raising. — The membership in the pig club this year was nearly double that of last year. The work was confined to sections where it was believed it properly belonged. The contest opened June 1 and closed October 1. Each member was required to feed and care for his or her pig or pigs in person, and keep a record of feed given and pasture grazed. The weight was asked for the first of each month during the contest, and from these reports the daily gain was figured. Enrollment for 1916, 634.

Home Economics. — While the work of this club was designed primarily for girls, a goodly number of boys have entered certain phases of it. The contest runs for three months, and during this time sixty hours of work is required. Two sets of prizes are awarded in this club, and contestants elect as their "major," to which they must devote at least twenty hours, either bread making or garment making, selecting from a list of over twenty-five, other home duties sufficient to make a total of at least sixty hours' work. In order to be among the contestants for the major prizes one must send in three time sheets (one each month), also three rank sheets and a story of experiences in the club work. An effort is made to visit each group to see the exhibition of products made by the club members. The exhibition at Orange stands out as being the finest in the State for 1916. There were 96 girls enrolled in the Home Economics Club in Orange; 93 of these girls "came through," completing every requirement in the club. Enrollment for 1916, 2,884.

Canning and Marketing. — The enrollment in the canning club was much larger than last year, and much better results were obtained from following the cold pack method. Only one report is required, this being the final record of the amount, variety and value of the fruit, vegetables and greens put up during the contest. The members are required to exhibit at least six jars, two of each variety; that is, two fruits, two vegetables and two greens. Enrollment for 1916, 1,201.

Organization.

This work in the future is to be known as "junior extension club work," as this title seems to fit the real character of the work better than the term "boys' and girls' clubs." The supervisor of this junior extension club work is responsible for the organization of the work, both in the field and in the office.

The co-operating agencies are the State Board of Education, State Board of Agriculture, the county farm bureaus and leagues, the United States Department of Agriculture, town and city school departments, Parent-Teachers' associations, School and Home Association, women's clubs, chambers of commerce, boards of trade, granges, business firms and interested individuals.

Supervision.

Up to July 1 the work was supervised by Prof. O. A. Morton, whose resignation went into effect at that time. The first few months of the year were spent in organizing clubs and giving assistance to the county agents. A great many schools were visited at which time club work was discussed. Oftentimes the mornings and afternoons were spent visiting schools, and the evenings were given to illustrated talks arranged by local organizations. After the clubs opened the time was spent in follow-up work.

During July a conference for country school teachers was held at the college. Club work was strongly emphasized in these meetings, and several teachers who had done particularly fine work in their own communities were asked to relate their experiences.

The present supervisor took up his work on September 1. Most of the fall was given up to the Eastern States Exposition at Springfield. Since the exposition, in October, the time has been devoted to closing up the 1916 clubs and obtaining the results of the contests.

Mr. E. N. Boland has been in charge of the pig club work and has devoted his entire time to it. During the contest he visited as many members as time would permit, in order to give advice and learn by observation what improvement could be

made in the work. He also spent some time in securing pigs for club contests. The agent made special effort to get into personal contact with the members, and help them with their individual problems. Since the contest closed, October 1, it has been necessary to spend considerable time scoring the pigs.

Mr. Boland resigned as pig club agent December 1, and will be succeeded by Mr. V. A. Rice.

Miss Ethel H. Nash, assistant club leader, has devoted her entire time to the home economics and canning clubs. January and February were spent in organizing clubs and assisting the county agents. Then came the follow-up work by letter and by visits, at which demonstrations were given in bread making and in garment making. Several months were spent in connection with local exhibitions of club work, at which club members exhibited their bread and sewing to be judged. Owing to the work at the exposition, the judging of the products of the canning club members was much delayed.

Exhibits.

Too much emphasis cannot be laid upon the exhibit work and the establishment of standards, because of their great value from the standpoint of better production and marketing. Every member is urged to exhibit locally, and also at one or more of the agricultural fairs. During the home economics contest 369 loaves of bread and 587 pieces of sewing were exhibited.

In January the annual exhibit of the State Board of Agriculture was held at Horticultural Hall, Boston, Mass. The quality of the products shown by the boys and girls was better than ever before. The canned products attracted a great deal of attention and favorable comment from all the visitors.

The largest piece of exhibit work accomplished during the year was in conjunction with the Eastern States Exposition in Springfield last October. The ten North Atlantic States cooperated in making this exhibit a success. Massachusetts boys and girls captured 3C1 prizes. Some idea of the size of the exhibit may be gained from the following: 50 exhibits of eggs, 1 dozen each; 168 exhibits of corn, 10 ears each; 386 exhibits of potatoes, 20 potatoes each; 533 exhibits of vegetables;

3,500 jars of canned goods; 150 loaves of bread; 235 chickens; 39 pigs.

In addition to the above there were large exhibits of farm and home handicrafts and sewing. Pictures and charts showing the nature of the work were also displayed.

During the days of the fair, demonstrations were given by boys and girls of various clubs showing work in canning, sterilizing of dairy implements, caponizing, the making and planting of a garden, dry picking, Babcock test, making of potato crates, making of maple-sugar products from the syrup, sour-milk cheese, bread making, butter making, potato demonstrations showing the selection of seed potatoes and treatment for scab, and the selection of seed corn.

The following prizes were won by Massachusetts: —

	First.	Second.	Third.
Corn project,	2	9	15
Canning,	1	7	9
Bread,	2	10	9
Sewing,	5	8	9
Poultry,	8	9	25
Farm and home handicraft,	4	7	8
Pig,	2	5	9
Market garden,	19	33	36
Potato,	2	4	9

One of the rules of the pig club was that each member should exhibit his or her pig at a local fair. Because of the infantile paralysis epidemic this rule could not be enforced. Exhibits, and the number of pigs shown in each instance, were held as follows: Topsfield Fair, 12; Wilbraham Fair, 3; Framingham Fair, 6; Cummington Fair, 6; Northampton Fair, 9; Pittsfield Exhibit, 5; Greenfield Fair, 14; Brockton Fair, 42; Swansea Grange Exhibit, 4; Springfield Exhibit, 33.

Prizes.

To the 25 club members having the highest scores in each club are awarded prizes as follows, one first and several second, third and fourth prizes usually being given: —

First Prize. — Trip to Washington.

Second Prize. — New England trip.

Third Prize. — A week at M. A. C. camp.

Fourth Prize. — Prize not exceeding $1 in value (usually a book).

The 1915 first prize winners went to Washington on February 27 and returned March 3. The party was chaperoned by Miss Mabel Turner of Milton and Mr. E. J. Burke of Hadley.

The 1915 second prize winners' trip was taken in October. Owing to lack of funds we were unable to give them a trip similar to that of last year. An automobile trip was taken through western Massachusetts, and a day was also spent at the National Dairy Show.

The boys' and girls' camps were held for the third prize winners during July, as is the custom.

Summary.

The results of this work already show that it furnishes a form of education which develops the child mentally, morally and physically. It furnishes one of the finest types of manual training at a per capita cost that no other work has in any way approximated.

As the children grow older they should be interested in undertaking different projects that will require an entire year for completion. Emphasis should constantly be placed upon their ultimately earning and saving for advanced education.

Time shows conclusively that the success of the work depends upon securing the right person to act as local supervisor.

The future development of the work calls for more supervision from the college, with a larger clerical force to attend to the ever-increasing amount of statistical detail; more supervisors in local districts, with some plan developed for the training of these supervisors; closer correlation with farm bureaus, with assistants in the bureaus for the department of junior work.

A great deal of the credit for the success of this work should go to the county agents and high school men, who have offered a great deal of assistance.

The financial support given for pig club work by four of the packing houses has been very acceptable, and the agent has tried from time to time to keep the donors posted as to how the work progressed.

Special mention should be made of the interest in club work taken by Mr. Holland, president of the Plymouth County Trust Company. This year 380 pigs were given out by this company for which a note was given by the boys and girls for the value of the pig at that time, payable after December 1. At the time the pigs were given out, each one receiving a pig was enrolled in the pig club, and the pig club agent was assisted in the follow-up work by the agricultural agent employed by the trust company. Twenty-five heifer calves were also given out.

In one district, Framingham, Mr. S. L. Elberfeld was engaged to devote his entire time to club work. This work was carried on in five towns in Middlesex County. Mr. Elberfeld had a very good system of follow-up work, and the results of his efforts, in one instance, have been shown in the poultry contest, as several of the 1916 prizes in this contest have been awarded to contestants in this district.

Statistics.

Counties interested,	13
Towns and cities,	359

Club Membership.

Market garden,	1,361
Corn,	172
Potato,	504
Home economics,	2,884
Poultry,	1,033
Pig,	634
Canning,	1,201
Home and school gardens,	40,557
Calf club,	75
Total membership,	48,421

Records of a Few 1916 Canning Club Members.

	Quarts.
Ethel Spooner, Brimfield,	372.0
Gladys Harlow, North Easton,	369.5
Hermine Schulz, Roslindale,	337.5

	Quarts.
Helen Streeter, Cummington,	298.0
Nellie Streeter, Cummington,	294.0
James Spadea, Brockton,	278.0
Ella Buckler, Pittsfield,	249.0
Daniel Harkins, Brockton,	230.0
Grace Depoyan, Bridgewater,	226.0
Cecelia Conlin, Hopkinton,	216.5
Mary Kelliher, Brockton,	205.5
Everett Mayo, New Bedford,	200.0
William Spooner, Brimfield,	189.0

1916 Home Economics Club.

Number of members completing the required time,	569
Number completing every requirement,	489
Number of loaves of bread made during contest,	9,983
Number of bread exhibitors,	369
Number of sewing exhibitors,	587
Number of stories received,	559
Total number of reports received (time and rank sheets),	6,729

Data concerning Miss Nash's Work.

Number of towns visited,	133
Number of schools visited,	96
Number of individuals addressed,	7,510
Organizations visited,	15
Number of exhibits held,	69
Number of bread demonstrations held,	7
Number of sewing demonstrations given,	3
Number of canning demonstrations given,	10
Judging teams trained,	7
Number of conferences attended,	19
Number of personal letters written,	1,474
Number of circular letters written,	26,758

Data concerning Professor Morton's Work Dec. 1, 1915, to July 1, 1916.

Lectures, 218; attendance,	28,590
Conferences, 79; attendance,	645
Demonstrations, 11; attendance,	880

Data concerning Professor Farley's Work.

Lectures, 8; attendance,	235
Conferences, 21; attendance,	92

REPORT ON PRINTING AND PUBLICATIONS.

The cost of printing has risen greatly during the past year, due very largely to the enormous increases in all kinds of paper stock and printers' supplies. This has made it impossible to print as much material as would otherwise have been the case, and will still further reduce the amount during the coming year. We are continuing to secure estimates on all the larger jobs, and are dealing only with those houses whose equipment and ability to render the service desired qualify them for consideration.

A plan for the classification of extension publications was presented and adopted early in 1916, and all extension publications now fall in the following series: —

Extension Circulars. — This series includes all publications of a technical nature from 1 to 4 pages in size.

Extension Bulletins. — This series includes all publications of a technical nature over 4 pages in size.

Extension Announcements. — This series includes all announcements and programs of different phases of extension work, regardless of size.

Massachusetts Bulletin for Farm Women. — This includes all publications containing technical information on home economics subjects, regardless of the number of pages.

Facts for Farmers. — This series was formerly issued as a monthly publication dealing with technical subjects, and has now been discontinued and similar publications included in the extension circular series.

Monthly Journal of Extension Work for Market Gardeners. — This series is issued monthly in connection with the Boston Market Gardeners' Association. Each issue comprises a report of the work done during the previous month by the market garden district agent, and an article on some timely subject.

Library Leaflets. — This is a series of single sheets, giving lists of books and periodicals on specific subjects.

Boys' and Girls' Series. — This is a series containing technical information upon the subjects covered in the boys' and girls' club work. These publications are also included in the series known as extension circulars or extension bulletins, according to the number of pages they contain. Eventually this will probably be made a separate series.

Numbers in these series were assigned to those publications issued between Jan. 1, 1916, and the time when the classification was authorized. The establishment of a series of bulletins

for the Polish farmers of the State is under consideration. These will be printed in that language, and will consist of the lectures given on Polish Farmers' Day and of translations of other available and appropriate literature.

During the year 54 extension publications have been issued with a total of 468 pages, with a total issue of 201,500 copies; these have ranged from 1 to 32 pages in size. This does not take into account the thousands of record blanks, application and enrollment cards and blanks, posters, letterheads, schedules and other miscellaneous printing. These are not listed in the statistics given in connection with this report, but they represent no small item in the course of the year.

Publicity.

There is great opportunity for a large amount of very effective and telling publicity work in connection with the various phases of the Extension Service more than has been permitted by the exigencies of other work. The regular news letter has been continued, and has been utilized very extensively by the newspapers of the State and by the agricultural periodicals. Special news letters and items have been issued as emergencies demanded. Abstracts of lectures during farmers' week, the Poultry Convention and the Conference on Rural Organization have been prepared and sent to a selected list of papers, as well as furnished to representatives of the press who have been present. Every possible courtesy is extended to regular and special press representatives during their visits to the college at such times, and these efforts are very fully appreciated. A number of special articles bearing upon the work have been prepared for various publications during the year.

If the various activities carried on by the college are to yield the utmost in results and beneficial effects, the college certainly has a distinct and definite duty to perform in acquainting the public with the facts in the case. The several activities of the Extension Service can reach their greatest usefulness only as adequate publicity is given them. If the people's money is to go into these activities it is the duty of

the college to avail itself of all possible means of acquainting the people with the opportunities which are thus opened to them. Adequate publicity is certainly the primary way in which this can be done.

Committee on Publications.

During the past year a committee on publications has been appointed. This committee has general oversight of all college publications, and consists of the following members: the director of the experiment station, the director of the Extension Service, the director of the graduate school, the secretary of the college, the extension editor.

Statistics.

Publications.

Titles of Series.	Number of Individual Issues.	Number of Pages.	Number of Copies.
Extension announcements,	9	67	36,500
Extension circulars,	9	36	83,000
Extension bulletins,	10	136	39,000
Boys' and girls' series (not included in extension bulletin or extension circular series).	1	32	1,000
Massachusetts bulletin for farm women,	2	32	10,000
Monthly journal of extension work for market gardeners.	12	48	6,000
Library leaflets,	5	5	6,000
Facts for Farmers,	4	16	12,000
Publications issued in co-operation with other organizations.	2	96	8,000
	54	468	201,500

Publicity Work.

Regular news letters,	15
Words per letter,	1,200
Papers receiving,	225
Special news letters,	5
Lecture abstracts,	33
Special articles,	18

REPORT OF LIBRARY EXTENSION WORK.

The following statistics indicate the activities in library extension work for the year ending Nov. 30, 1916: —

Libraries receiving books,	39
Volumes sent out,	679
Bulletins, pamphlets, etc.,	49

An additional feature which we hope to make a great deal of this year is that of sending out special collections in connection with boys' and girls' club work.

This will increase the work of this office a great deal, and at this point the writer desires to emphasize the need of additional financial and other support for this work. Our annual apportionment has been $200 for the past three years.

Another added item of expense is placed upon our budget by our trying to take care of the home economics work, and it would seem that we ought to receive something further in the way of clerical help in order to take care of the proper selection of material, charging and discharging of accounts, sending out shipments, and all the other details connected with this phase of the library work.

It is hoped that before very long we can have a part-time assistant, that is, a regular library employee reimbursed for part time by the Extension Service.

REPORT OF EXTENSION WORK IN LOCAL COMMUNITY ORGANIZATION.

The Aim in the Year's Work.

The activities of this year have concerned themselves very largely with the co-ordination of agencies, — State, county and town. It has been an effort to develop definite, practical, comprehensive plans and policies for improvement. The organization of the local community is the crux of the question and the adequate plan for rural progress. This does not mean the organizing of anything new, but merely the placing of the

various interests — organized or unorganized — of the community in the best possible working relation to each other. The work with State and county organizations is being done because they are contributing factors to the development of the local community. The spirit of co-operation on the part of those involved was a great factor in the marked success of the year's work. Co-operation without reserve was given by a number of State organizations, boards and institutions, the county agricultural schools, the county farm bureaus and many voluntary county organizations as well as numerous local organizations. Of the local agencies the agricultural instructors in high schools should be mentioned especially.

During the past year work has been done along the following lines: —

A. Co-operation of County Farm Bureaus.

A co-operative project in local community organization has been carried on with the county farm bureaus and improvement leagues in the counties of Barnstable, Berkshire, Essex, Franklin, Hampden, Hampshire, Norfolk, Plymouth and Worcester. With very few modifications the project is as follows: —

I. Co-operative study between the............Farm Bureau and the ....of local community organization work of the Extension Service of the Agricultural College.

General scope, viz.: —

1. To study the county as to county-wide organizations at work, their purposes and the lines along which they expect to work during the coming year; also a study as to any outstanding problems which may be before the county.
2. To study each town of the county as to the organizations working within the town, industries, types of agriculture and special needs of the town as they may be gotten from the surveys and from representative people who may be in position to know.
3. To study the chief needs of each town, having in mind its larger development along the lines of industry, including agriculture, public health, transportation, recreation, home life, etc.
4. To list every town as to the next steps, also as to long-term plans for its development.

II. Community organization.
  1. Direction of towns already at work.
  2. Advice to new towns.
  3. Lectures on community organization or allied subjects in such towns as may desire them.
  4. Direction of each town in some item of self-study, such as dairying, fruit growing, recreation, public health, etc.
  5. Assistance to each town in working out one or more definite projects to be followed next year.
  6 Inducing a few towns to work out a definite, comprehensive community development plan.
  7. Securing co-ordination of local organizations whenever this is possible rather than to organize anything new.

III. County conferences (time, 1 week).
  1. A conference of agents representing organizations working within ....County.
    (*a*) To exchange statements as to the general scope of work each is pursuing. This is partly a matter of getting acquainted with what each organization is promoting.
    (*b*) To exchange working plans for next year.
    (*c*) To work out any possible plans of co-operation between organizations. In a number of instances other organizations have assisted the farm bureau in carrying out its work, and *vice versa.*
    (*d*) To study the county as a whole in an effort to determine its larger problems, and work out if possible a rural policy for the county.
  2. A conference of leaders from the various communities of the county similar to those in Barnstable, Essex and Hampshire counties during the past three or four years. Details to be determined later.

B. Co-operation of Agricultural Instructors.

This has extended to instructors in the towns of Hadley, Hardwick, Petersham, New Salem, North Easton, Ashfield, Reading, Brimfield, Leominster and Sutton.

With slight variations this work has comprised —

1. A survey of the community.
2. Assistance with special events, such as celebrations, etc.
3. Planning specific projects on community-wide basis.

C. County Conferences.

1. *On Community Organization.* — General conferences were held in the counties of Barnstable and Hampshire. These comprised a general get-together of the people interested in the various phases of agriculture and community life, to consider methods of organizing the community for definite work.

2. *On County Organization.* — Conferences were held in Essex and Barnstable counties. These comprised a get-together of representatives of county-wide agencies which followed the plan outlined in the farm bureau project above (see A. III. 1), and resulted in thorough understanding and co-operation among organizations, and a beginning of definite planning for the agricultural and general rural affairs of the county.

D. Extension Schools.

Extension schools in community organization were held in the communities of Sutton and Westminster. These took up the organization phases of agriculture, education, the home, civic affairs, recreation, transportation, public health, etc. Two two-day meetings were conducted jointly with the Worcester County Farm Bureau in Princeton and Petersham.

E. Community Organization.

This involves a pulling together of all the organizations and interests of the community in a planning for the future along all lines of agriculture and community life. Follow-up work has been carried on in the following towns: Bolton, Hubbardston, Tyringham, Wilbraham, Hardwick, Brimfield, Chartley, Westminster, Montague, Sterling, Charlton, Billerica, Walpole, Shutesbury, Lanesborough, Harwich, Framingham, Berlin, Littleton, Norwood, South Athol, North Dana, North Leominster, Chester and Sutton.

Community organization work has been started in the following towns this year: Pepperell, South Ashburnham, Plainville, Princeton, New Salem, Heath, Ashfield and Petersham.

F. The Massachusetts Federation for Rural Progress.

The secretaryship of this organization has been held by the extension professor of community planning. The Federation now comprises some twenty-eight State organizations, boards

and institutions. It is centering its activities this year on the following projects: —

1. A plan for the exchange of memoranda concerning plans and projects which each organization, board or institution proposes to follow during the coming year.
2. A plan for the improvement of the production of the dairy industry in Massachusetts.
3. A plan for the improvement of the marketing aspects of the dairy industry in Massachusetts.
4. An educational campaign concerning rural credit, consisting of conferences, publicity, etc.
5. A plan for co-operation among county agencies in Massachusetts.
6. A plan for the improvement of the home.

G. *The Massachusetts Development Committee.*

During the past year the extension professor of community planning has also served as a special agent of this committee, which is comprised of representatives of the Massachusetts Agricultural College, State Board of Agriculture, State Board of Education, State Grange, the Federation of Farm Bureaus and the Association of Instructors in County Schools and Vocational Instructors in Agricultural Departments in High Schools.

Special Needs. — There are several lines of work which the writer has developed, appreciating the fact that he was merely getting a start with them. Your attention is especially called to the extension schools in community organization, both forms of county conference, special community conferences, the Massachusetts Federation for Rural Progress, as well as the work of the vocational agricultural instructors. During the past two years these lines of work have been developed to where they consume a large amount of time and energy. The work already started in various communities necessitates much follow-up work. With very little publicity there have been a very large number of calls for help by new communities. This leads me to feel that if some of these lines of work are to be pursued with any thoroughness some assistance in the general conduct of the work is absolutely necessary. This matter was mentioned last year. The time has come to get some assistance or curtail some of the lines which have been started.

Statistics.

Conferences held,	170
Attendance,	907
Lectures given,	55
Attendance,	2,788
Extension schools in community organization,	2
Counties working under community organization project,	10
Agricultural instructors co-operated with,	10
Communities continuing community work from last year,	26
Communities beginning community work this year,	8
County conferences held,	4
Massachusetts Federation for Rural Progress conferences,	16
Massachusetts agricultural development committee conferences,	18

REPORT OF CORRESPONDENCE COURSE WORK.

General Statement.

One of the first methods of extension teaching to be adopted by the Massachusetts Agricultural College was the correspondence course. This is one of the most far-reaching methods which is being utilized, for it opens the door of opportunity to each and every person in the State who can be reached by our all-embracing mail service. Occasionally one hears criticisms of correspondence teaching as a method of instruction. It will usually be found that the person who speaks slightingly of this system of instruction either has never taken up any study in this way or else has attempted it, but, owing to lack of tenacity of purpose or initiative, has failed to carry it through; as a usual thing it is the *person* and not the *system* which is at fault. The good which a person gets out of the work is directly in proportion to the amount of effort that person is willing to put into it. In fact, there are some institutions which feel that their most effective work in some subjects is done by correspondence.

Purpose and Description of the Work.

In every community there are many people who realize that the period of education should not be confined to what is ordinarily known as "school years." It is to meet the needs of such persons who desire authentic and reliable instruction

in agriculture, horticulture, home economics and allied subjects that the correspondence courses are conducted. College credit is not given for any of the courses which are offered. The primary and underlying purpose of the work as a whole is to make agriculture in its various branches more profitable to those who are engaged in it, and to make life in the farm home and the farm community more pleasant and satisfying.

Farmers, live stock producers, poultrymen, fruit growers, market gardeners, homemakers, teachers, ministers and other rural leaders will find courses of especial interest and value. A large demand for the courses has also come from another source, namely, residents in towns and cities who are planning sooner or later to go into the country and engage in some form of practical farming. Such persons find in the correspondence courses an excellent opportunity for preliminary study and preparation. The object of these courses is to present the latest information upon the several courses offered in as condensed and practical a form as possible, and yet comprehensive enough so that even the beginner may secure a good working knowledge of the subject.

The courses are prepared by members of the college staff, and consist of three distinct types, — first, assignments in standard textbooks adapted to the purpose; second, typewritten lectures prepared by the faculty of the college; third, a combination of the two. Probably the most satisfactory of the three is the last one named, and the tendency is toward the adoption of this method in connection with the various courses which are offered by the college, in so far as possible. Each lesson eventually will consist of five parts, — the lesson itself, a reading assignment in some standard textbook, a glossary of technical terms, questions upon the lessons, and an assignment of practical or laboratory work. The close relation of practice to study cannot be emphasized too strongly. Whereever it is possible students are urged and in many cases required to actually *do* the things about which they are studying. In this way the desirability of doing things in the right way is more strongly emphasized than is possible in any other way.

The subjects which are now listed in the announcement of the work are: soils and soil improvement; manures and fer-

tilizers; field crops; farm dairying; apple growing; peach, pear, plum and cherry growing; culture of small fruits; vegetable gardening; animal feeding; floriculture; farm accounts; elementary entomology; specialized entomology; principles of agricultural teaching; beekeeping; forestry; shade tree management; gardening and elementary agriculture; poultry house construction; feeds, feeding, breeding and poultry management; incubation, brooding, growing of stock and poultry diseases; human nutrition; rural sociology.

Method of Conducting the Work.

Persons interested in the courses apply to the supervisor for descriptive literature and enrollment blank. The blank is filled out and sent in, accompanied by the necessary fee, which has been set at $1 for each of the courses. If everything is satisfactory, the introductory lesson on methods of study and the first lesson in the course itself are then sent. The student sends in answers to one lesson at a time, and upon the receipt of each set of answers the next succeeding lesson is sent. The answer sheets are referred to the department conducting the course, where they are corrected, suggestions are offered, questions are answered and the papers returned to the student. The work is conducted from October 1 to June 1 each year, and a person may register at any time between these dates. In case a person is so situated as to have a considerable amount of time to devote to the work during the summer months special arrangements will be made for their accommodation. One year is allowed for the completion of each course. The registration is limited to residents of Massachusetts or persons owning property in this State.

Wherever five or more persons in any given locality desire to take up the work together definite arrangements will be made for a group study class. All members of such a class must take up the same course. There are three outstanding advantages in taking up the work in this way, — first, added interest, enthusiasm, and the interchange of ideas and experiences which come from meeting together periodically for study and discussion; second, the possibility of having a specialist in the

subject visit the class once or twice during the course; and third, the sending, by the college, of a collection of books and bulletins on the subject for the use of the class.

Need of and Demand for the Work.

The demand for the correspondence courses is very adequately shown in the fact that the registration, without definite effort toward enlargement, continues in the vicinity of 1,000, the mark beyond which it is inadvisable to go with present funds and assistance. The fact that the work is continuously bearing fruit is evidenced by the many expressions of appreciation which are continually being received.

We are continually receiving letters saying that "if people only knew about the correspondence courses" that many more would take advantage of them. It is, however, unwise to make definite efforts toward expansion at the present time for reasons herein stated. It will be seen from the above that the correspondence courses tend to fill a very real need.

Work of the Year.

The general plan of the work during the past year has been very similar to that in previous years. With the funds and the clerical assistance now available, it is only possible to mark time. Neither is sufficient to warrant definite advancement, either in the preparation and offering of new courses or in the way of enlarging the enrollment. It has seemed advisable to seek outside sources of support for the work. A definite plan of procedure was jointly drawn up by the supervisor and the director of university extension of the State Board of Education, whereby $2,000 might be apportioned by that Board to the correspondence work of the college. The Board as yet has not taken action upon this matter.

All lessons must now be sent as first-class matter. It seems to the writer that correspondence instruction might legitimately be included as a Lever bill project, and the lessons sent under frank. This has been taken up with the States Relations Service.

It would seem sound policy for the State to adequately support the correspondence courses in agriculture and home eco-

nomics, as such, and we should not be forced to go to other organizations for financial aid for which we must, and justly so, grant a certain amount of supervision which eventually may prove burdensome. Credit for work done under a co-operative agreement must also be shared with the co-operating agency.

Since Professor Haskell's departure the direction of the work in Courses 1, 2 and 3 has been taken over by Professor Jones. A rearrangement and enlargement of the courses in animal husbandry and dairying is now under consideration. This is especially desirable in view of the proposed State-wide dairy improvement project for 1917. Mr. Kilham has taken hold of Course 5 in fruit growing, and is rapidly completing Part I., on apple growing, and is at work on Part III., on the culture of small fruits. Course 8, in floriculture, has been sadly in need of revision for several years. It has been impossible for the department of floriculture to give this course the necessary attention, and the course has therefore been dropped this fall until a new course can be prepared. Course 9, in farm accounts, is at present undergoing revision and simplification, and the new course will be ready January 1. Dr. Regan has given very conscientious attention to students in Course 10, in entomology, and has worked out under Part II. special work along the following lines: orchard pests; apple insects; small fruit pests; market garden and field crop pests; greenhouse pests; forest and shade tree pests; domestic animal pests; household pests and those attacking man; popular medical entomology. A student may elect any one of these after having taken up Part I. on elementary entomology. Professor Hart has found it impossible to rewrite the course on principles of agricultural teaching during the past year. Following the resignation of Dr. Stone, the work of the shade tree management course has been conducted by Professor Osmun. It was impossible for Professor Morton, before his resignation, and has been for Mr. Farley since taking up the work, to get out a new course on gardening and elementary agriculture for school teachers and garden leaders, although this is now under consideration. There has been considerable demand for Part II. in the home economics course, on household management. It has, however, been impossible for our home

economics workers to get this in shape. Two of the group study classes which took up Part I. last year have been very anxious to take up the second part this fall, and quite a number of individuals have also expressed their desire to do this. Professor Phelan is now at work upon a revision of Course 19, on rural sociology, which will be practically equivalent to the course offered to resident students.

Future Needs and Plans for Development.

1. In this connection a reiteration of the statement contained in last year's report would very adequately cover the ground. Summarized, the essential needs are as follows: funds to be devoted to the preparation of new courses; additional help in correcting papers, and funds for meeting this expense; more clerical help; a larger apportionment for supplies and maintenance.

2. Negotiation with the department of university extension of the State Board of Education will be continued in the hope that funds may be granted, as is the case with other institutions, for co-operatively conducting the work. Efforts to secure the frank for use in connection with the lessons will also be continued.

3. An index is being prepared for each course, this to accompany the last lesson. This will make the book of lessons of much greater value to the student.

4. The group study plan will be further developed as funds permit.

5. In the organization of study groups, and in co-operating with county agents and local organizations, the desirability of information regarding students in different localities is more and more frequently emphasized. To meet this need a geographical index of students is contemplated. This will be established as soon as time will permit. Such an index will serve also to call attention to those communities in which little is now being done in this line of work.

6. The college is teaching numerous subjects at the present time for which there would undoubtedly be an active demand if correspondence instruction could be offered in them. At the

present time it is impossible to consider such further development of the work.

7. The great majority of our State universities and agricultural colleges are now offering correspondence instruction in one form or another. The writer has in previous reports called attention to the need of a periodical get-together meeting of those in charge of this work in State institutions. A national organization of correspondence course workers, holding annual meetings, would be of inestimable value in the development of this work. Others with whom the writer has corresponded are emphatic in their approval of such a plan.

Co-operating Organizations.

In a number of instances local organizations, such as the grange, the church or the woman's club, have co-operated in the formation of classes as well as in furnishing meeting places. In nearly every instance the librarian is very willing, indeed, to have group study classes meet at the library, provided there are adequate accommodations, and to pay the transportation charges on the books. The supervisor has worked through the farm bureaus and county agents as far as possible in connection with the study groups.

The supervisor has also kept in very close touch with the department of university extension during its development, and conflict and duplication of effort have thus been avoided.

The supervisor would like here to acknowledge and to express his appreciation of the cordial spirit of co-operation which exists among the various departments on the campus which are conducting the several courses, and to thank each person individually, in behalf of the Extension Service and of the students who are taking the work, for the valuable service which they are so capably giving.

Statistics.

Active enrollment (persons) Dec. 1, 1915,	759
Persons enrolled during year,	498
Persons reached during year,	1,257
Persons completing and dropping work during year,	348
Active enrollment (persons) Nov. 30, 1916,	909
Group study classes at work during year,	10
Average enrollment,	9.3

REPORT ON ITINERANT INSTRUCTION.

Lecture and Lecture Courses.

The manner of carrying on the lecture work this year has not been changed materially from that of previous years. In so far as possible, the practice followed by a few organizations of asking only a few days before a meeting for a "good live speaker who could interest their audience" has been discouraged. We have insisted that calls for speakers be limited to certain definite subjects, which, in the opinion of the correspondent, would be of special value to the group receiving the talk.

We have insisted that in so far as possible we be given at least two weeks to arrange for speakers, and a great deal more time than this has been advised.

The result of this practice is that many organizations, especially granges and farmers' clubs, are now planning for their help from the college as much as a year in advance.

The more complete organization of the county work has affected our lecture work, in that requests for speakers are now most apt to come in through the county agents. To the extent that the county man is able to look ahead and foresee the calls, this has been a distinct advantage.

A number of the extension men have been called to these counties for series of talks and demonstrations on succeeding days in different parts of the county, which is, of course, a better use of time, energy and money than a trip for each lecture.

We have inaugurated what we believe to be a better system of keeping record of lectures given by the general faculty, to the end that we feel that the statistics on page 109, covering lectures, conferences and visits, are as near accurate as can well be obtained.

We have divided the report into lectures, conferences and visits, in order to suit the nature of the work done by the different members of the force. The term "lecture" has been used to describe a more or less formal talk at a meeting where there are ten or more people present. The term "conference" is used to refer to a meeting at which an informal discussion is

held and generally attended by less than ten people. The term "visit" is used with special reference to certain kinds of work, where simply a visit is made, sometimes only one person being seen, sometimes more. It may apply to a farm, a school, a boys' or girls' project, or a demonstration orchard.

For the more formal lecture trips the communities almost invariably bear the traveling expenses of the speaker. For the trips made to visit some piece of work in progress, or to organize some new work, the college usually meets the expense of the trip.

Exhibits.

The chief exhibit work attempted by the Extension Service for the year has been that connected with the agricultural fairs during the past season.

A sufficient number of calls came in from the smaller fairs so that an itinerary could have been made up so as not to have visited any fairs which had been visited before. Most of the smaller fairs, however, would not have been able to pay our stipulated sum of $75 to help defray expenses. In addition, our presence at the smaller fairs would have brought us into touch with a much smaller number of people. The thing which, after careful consideration, it seemed best to do was to change our exhibit so that we could visit a good list of the better fairs of the State, thereby reaching a large number of people as usual.

It has been the policy of the Extension Service at all times to make the exhibit material interesting, attractive and educational. The exhibit feature has, on the other hand, been considered largely a means of bringing people to the tent in order that they might profit by lectures and demonstrations which were given there.

With these things in mind, an exhibit was planned to consist of cows obtained locally around each fair, on which the owners had accurate records for the year. In so far as possible, cows were obtained which had been in a cow test association for one or more years. A plan was worked out by which each visitor as he entered the tent was asked for an expression of his judgment as to the relative producing power of the eight cows before him. This judgment he left in the form of a slip of

paper which he filled out, carrying a copy of it away with him. All visitors were asked to return at specified hours to hear the actual records announced.

To say that the interest manifested at these fairs was fully up to our expectations is putting it too mildly. Contrary to most exhibits, the more practical a man was the more this exhibit appealed to him.

The whole exhibit, and the talk given at least twice each day, centered on the all-important matter of records, and the exhibit, plus the contest, emphasized the need of records, as could have been done in no other way.

The value of milk and the factors in proper handling came in for their share of attention, both in the exhibit and lecture work.

In order that the tent might hold attractions for him who was not a real dairyman, a fine exhibit was taken from the college poultry plant.

Here, again, record keeping was emphasized, both in exhibits and in the educational lectures and demonstrations given. The highest form of teaching, that done by contrast, was employed. Good and poor specimens, from the standpoint of vigor, egg-laying ability, hatchability, maturity, etc., were shown side by side. The importance of selection and mating and care in the poultry flock were emphasized in a number of ways.

One of the primary needs of the exhibit work is for some one with sufficient ability to arrange some few new features around which to center other materials from year to year, and the necessary time and money to do this.

Having featured dairy work this year, then some other line, such as proper methods of growing fruit, should be featured for next year.

On the whole, the agricultural societies have been very glad to feature the kind of educational work conducted by the college.

In addition to the fair exhibit work above described, some special exhibits were put on by various departments of the college.

The poultry department co-operated with eight poultry shows by putting on educational exhibits of a similar nature to the exhibit sent out to fairs.

The dairy department has, for a number of years, been closely identified with all the milk shows of the State, going, in some instances, to the extent of staging the show, arranging for the judging, and in general making the analyses. During this year representatives of this department have worked in the large show held in Boston, the fine show held as a part of the farmers' week program, and in the show held at the Fitchburg Fair for the second time.

Fair Exhibits, 1916.

Fair.	Number of Days.	Approximate Number of People visiting the Exhibit.	Number of People passing Judgment on Cows.
Barnstable,	3	2,500	72
Worcester,	4	60,000	293
Southern New England,	2	12,000	191
Sturbridge,	3	4,000	169
Topsfield,	2	5,000	303
Framingham,	2	4,000	178
Greenfield,	2	12,000	433
Brockton,	4	33,000	523
Totals,	22	132,500	2,162

Extension Schools.

The usual calls for extension schools from individuals and organizations came in during the fall of 1915, and in addition, there was a very definite request from some of the county men who felt that time spent in arranging for and holding such schools was of as great value to the county as any other work which they could do. It was felt at the college that the co-operation of the county man in this work was a step in the right direction, as it tied up in a very definite way the work of the two organizations.

In only one county (Bristol) did the county agent do actual instructional work in the school. In the other counties, however, the county men gave varying degrees of assistance in making all the preliminary arrangements.

The necessity of changing men in both the soil fertility course and the course in animal husbandry contributed to a weakening of the schools for a time, near the middle of the winter.

The homemakers' part of the school was carried on with a large amount of skill throughout the year, and the good impressions left in every community are evidence enough of the usefulness and appreciation of this phase of the work.

The great need of the extension schools now, as in the past, is for competent instructors who are connected the year round with the college, and who will be willing to give every help possible while in the community. This will undoubtedly be still more true in the future.

A *genuine* interest in and sympathy with conditions on the farm counts here as in perhaps no other line of work.

Follow-up work for the extension schools has not up to date been very fully developed. At the end of every school a brief statement has been made to the effect that we wanted the school considered as an introduction to the general work of the college for the people of that community. The people have been requested to take advantage of this acquaintance with the college to secure more helps than ever before. In many cases these suggestions have been followed out, as can be seen by noting what communities have asked for more organized pieces of work, — farm surveys, selling organizations, correspondence classes, community schools, etc. The study groups organized in the homemakers' schools have been our most definite piece of follow-up work, but not necessarily the most lasting or effective. The effect of the school on the community as a whole is being brought to our attention almost every time we visit one of these communities.

Extension schools in community organization were held in two places during the year. The members of the faculty and outsiders who are asked to help in these schools are learning more and more to make their talks contribute to the general program of the community, and not to give them as units in themselves. The interest shown in this type of school in the communities where they have been held shows conclusively that there are some places ready to think of all their work in terms of the community.

Schools in which courses in agriculture and home economics were given were held in the following towns: Pepperell, Prescott, Barre, Chesterfield, Cummington, Grafton, New Bedford, Westford, North Attleborough, Northfield. The total attendance of these schools was 1,050.

Two schools in community planning were given, one at Sutton and one at Westminster. The attendance of these two schools was 120.

REPORT ON EXTENSION WORK IN POMOLOGY.

This report covers the period from Nov. 31, 1915, to July 30, 1916, when Mr. R. W. Rees was in charge of the work, and the period from Aug. 17, 1916, to Nov. 30, 1916, when the work has been in charge of the undersigned.

Demonstration Orchards.

The following is a list of our demonstration orchards: —

Planted 1910: —
E. B. Clapp, Westhampton, Hampshire County.
Frank T. Haynes, Sturbridge, Worcester County.
A. L. Fish, Colrain, Franklin County.
George C. Thurlow, West Newbury, Essex County.
Planted 1911: —
A. W. Bagnell, Enfield, Hampshire County.
L. B. Dickinson, Granville, Hampden County.
C. M. Ottman, North Adams, Berkshire County.
C. W. Wilson, West Medway, Norfolk County.
Planted 1912: —
H. A. Dunbar, Richmond, Berkshire County.
Planted 1913: —
C. W. English, East Brookfield, Worcester County.
Frank H. Taylor, South Hanson, Plymouth County.
Planted 1914: —
Gustaf Anderson, Pepperell, Middlesex County.
Joseph B. Cobb, Chicopee Falls, Hampden County.
Walter Sampson, Middleborough, Plymouth County.
Planted 1915: —
Henry L. Green, Paxton, Worcester County.

Because of the lack of sufficient funds no new demonstration orchards have been planted this year. The orchard on the farm of Mr. Edward Sturgis of Ballardvale has been discon-

tinued because of his failure to carry on the work as provided in our contract with him.

The work in these orchards the past year has taken much the same form as in previous years. The orchards, on account of their number and because of their increased age, are requiring more and more attention all the time.

From now on it will be necessary to direct the work in spraying the orchards planted in 1910 and 1911, and to help these owners with their packing and marketing.

Most of the orchards have made a very good growth and have done well in every way this past season. Because of the wet season and the lack of labor throughout the State many of the orchards have not received as much cultivation as is desirable. Special efforts must be made to remedy this condition another year. The orchards at Westhampton, Sturbridge, Colrain, West Newbury, Granville, North Adams, Richmond, Middleborough and Paxton are in very fine condition. Those at West Medway, East Brookfield, South Hanson and Pepperell are in medium condition, while those at Enfield and Chicopee Falls are in very poor condition. The poor condition of some of the orchards is largely due to poor handling. A part of the North Adams demonstration orchard is in very fine condition, while another part which was planted in wet ground is in rather poor condition. It is to be hoped that all of the demonstration orchards can be brought up to standard another year.

Each time the demonstration orchards are visited a report is written out and carefully filed. These reports are quite complete to date. The financial records of the various orchards are in very poor condition, and the records on certain orchards are completely missing for some years.

The owners of the demonstration orchards report a great deal of interest in their communities in the orchards and the work that is being done there. The demonstrations held in the orchards have been well attended the past year.

Extension Schools.

Work in pomology was given at ten extension schools. In half of these schools ten or eleven lectures were given which covered the whole period of the school, while in five cases only

five or six lectures were given. In connection with the extension schools a good many farm visits were made. At several of the schools, because of weather and other conditions, it was found inadvisable to make many farm visits.

Pruning Campaign.

Practically all of the pruning campaign work was in the form of demonstrations carried on in our demonstration orchards, or in co-operation with county agents. There has been a large demand for this work with the county agents, and the demonstrations in our orchards have proved very satisfactory for the most part. Plans are being made for the continuance of this work another year.

Pruning demonstrations were held in the following towns: Amherst, Lakeville, South Hanson, Pepperell, Abington, Norwell, South Hanover, North Middleborough, East Bridgewater, Greenbush, East Brookfield, Westborough, Grafton, East Taunton, Colrain, Granville, Richmond, North Adams, Sturbridge. The total attendance was 445.

1916 State-wide Apple-spraying Campaign.

The 1916 State-wide apple-spraying campaign, which was conducted in co-operation with the farm bureaus and the other organizations interested in the development of agriculture, was a success.

The county agricultural agents did a great amount of work in connection with this campaign. A few of the agricultural instructors in agricultural schools and in high schools aided with the work. The farmers showed a considerable interest in spraying and in giving their orchards a general cleaning up. That farmers are very much awake to the value of spraying is shown by the fact that it was very difficult to find apple growers who were willing to leave five trees unsprayed in order to take data to compare with five similar sprayed trees.

The data secured from the various orchards varied a great deal, as was to be expected. The value of the data lies in the fact that they were secured from a number of farms in all parts of the State, and that the figures represent actual farm

rather than experimental conditions. The following average figures will be very valuable for use in lectures by both the college force and the county agents: —

	Average.
Value of fruit per tree from sprayed trees,	$6 85
Value of fruit per tree from trees not sprayed,	1 83
Difference,	5 02
Cost of spraying, per tree,	52
Profit from spraying, per tree,	4 50
Increase in barrels, per tree,	1 38

Apple Grading and Packing Campaign.

The farmers throughout the State have shown a great deal of interest in this campaign this year because of the new apple law. Various members of the pomology department have taken part in this work, giving lectures and demonstrations in co-operation with the State Board of Agriculture and the county agents.

Apple Grading and Packing School.

This school, which is held annually on the college campus, continues to furnish instruction for a number of men who wish to learn better methods of putting up their fruit for sale. A full report of this school will be found in the report on the short courses.

Single Lectures.

Because of the large amount of work outlined for the past year it has been impossible to meet many of the organizations that have asked for lectures. Thirty-five lectures, with a total attendance of 3,103, have been given by the different members of the staff of the pomology department. These lectures have been before chambers of commerce, granges and various organizations of fruit growers.

Fruit Judging.

During the past year an unusual amount of fruit has been sent in to the college to be identified. In addition to this work a large number of calls have come in for judges for granges and various fairs. Members of the department of

pomology have judged fruit at Dighton, Harvard, Hartford, Conn., Greenfield, Amherst, Princeton, Bolton, Segreganset, Great Barrington, Northampton and Willimansett.

Extension Schools in Pomology.

Because of the pressure of the regular extension schools and other work it was found advisable not to hold any special schools in pomology the past year.

Correspondence Course.

The correspondence course in fruit growing has been planned and advertised to contain three parts, — Part I., apple growing, ten lessons; Part II., peach, pear, plum and cherry growing, ten lessons; Part III., small fruit production, ten lessons. The only lessons that have been prepared to date are those in Part I. These lessons were gotten out some years ago, and have been very successfully used, but because of the fact that they were out of date are now in the course of revision. Six lessons in the revised part are now being used. The other four lessons will soon be ready. There are 115 students registered in Part I. Some work has been done on both Parts II. and III., but because of the pressure of other work it will be impossible to complete either of these parts before spring.

Work at the Norfolk County State Hospital.

The officers of this institution have placed their orchards at our service, and express a desire to co-operate with us in every way that they can. These orchards are in no way under our supervision, but are available for our use.

Orchard Visits.

Most of the orchard visits are incidental to trips over the State for other purposes, but are very important, as they give the personal contact so necessary in our work. Many of these visits are made with the county agents. In the past year 101 orchard visits were made, exclusive of visits made for the purpose of demonstration. Twenty-four visits were made to

demonstration orchards. Twenty-three visits were made at the time of and in connection with the extension schools. Fifty-four visits were made with county agents and at other times when traveling over the State.

Conferences.

Each year it is necessary to meet in conference many individuals and committees. This work is very valuable because it tends to co-ordinate the work of the State and the nation. In the past year over fifteen important conferences have been held in addition to many of less importance.

Statistical Summary.

	Lectures.		Demonstrations.		Conferences.	Farm Visits.	Fruit Judging.
	Number.	Attendance.	Number.	Attendance.			
General work,	35	3,193	12	272	12	54	7
Demonstration orchards,	-	-	9	231	1	24	-
Extension schools,	81	2,728	-	-	-	23	-
Apple packing school,	6	46	4	41	1	-	-
	122	5,967	25	544	14	101	7

In the summary above no allowance was made for duplication of persons attending lectures at extension schools and the apple grading and packing school. Definite work was carried on in fifty-seven towns in the State.

Suggestions in Regard to Pomology Work for the Next Year.

In view of the fact that there will probably be no material increase in the amount of help in the pomology extension work during the coming year, we feel it inadvisable to try to develop any new lines of work. Some of the work that we now have planned in project form should be better organized and developed.

Four of our demonstration orchards should have good crops next year, and four others should have small crops. Next fall

these orchards should receive special attention in order to help the growers develop the best methods in picking, packing and grading their fruit. The orchards should be visited more frequently than they have been in the past, in order to properly supervise the methods and in order to secure necessary data. More time should be spent in properly recording these data, and in preparing them for publication and for use in lectures.

The correspondence course should be completed and the papers returned to the students, promptly and carefully graded.

An effort should be made to find more time for work with the county agricultural agents. The various campaigns outlined in the project should be carried on largely through and with the county agents. The three lines of work which should be emphasized this next year are, first, a continuation of the 1916 spraying campaign; second, a campaign for better methods of grading and packing our fruits; third, an advertising campaign to show the value of Massachusetts fruit and the use of these fruits in their best season.

Apple grading and packing schools held here at the college should be continued. It may be best to change the date of the school in order to insure a large attendance.

The other lines of work should be carried on in a manner similar to the way in which they have been conducted in the past.

There is a pressing need for an additional man to help carry on the work that is now planned. With our present force we can continue the lines of work we are now doing, and possibly perfect this work. Unless we have another man in this work very soon we cannot hope to properly carry out the plans that have been made for future development of this work. In addition to the work now planned several additional lines of work are in demand. The time of one man could be very profitably employed in the development of boys' and girls' work in the form of small fruits and orcharding clubs, and in aiding in the development of boys' and girls' judging contests and other similar work. A well-organized advertising campaign would be of untold benefit not only to the fruit growers of the Commonwealth, but to the housewife and to the general prosperity of the State. This work properly organized would require the

attention of one man for several months each year. Inasmuch as fruit is one of the chief agricultural products of the State, and because of the fact that the farm management surveys have shown that fruit is one of the most desirable cash crops for the general farm in Massachusetts, we feel that we should be given the force to properly develop this line of work which would mean so much to the Commonwealth.

REPORT ON EXTENSION WORK IN ANIMAL HUSBANDRY.

This report covers the different projects under which the extension work in animal husbandry for the year ending November 30 has been done.

Extension Schools.

Lectures were given at six different schools, five of them taking a full week's work in animal husbandry. In connection with these schools some farm visits were made, and they undoubtedly furnished a wider acquaintance with the farmers of the State, and to some extent opened the way for further work in the locality where the schools were held.

Milk Show.

Ten days were given to assisting in the work of preparing for and conducting the milk show held by the Massachusetts Dairymen's Association at the time of the annual meeting of the State Board of Agriculture, in Boston, Jan. 3 to 7, 1916.

Dairy Record Work.

Daily milk record sheets and monthly record books have been furnished on request. Some of these records sheets went to the county agents, others direct to milk producers. A record has been kept of those milk producers to whom the records were furnished, with a view to following up the work to see to what extent it is helping to eliminate the low producers. The county agents have also been asked to keep a record of those to whom they have furnished record sheets.

Dairy Improvement Associations.

No change has been made in the past year in the number of associations that are operating in this State. There are at present three of these associations, one in Middlesex County, centering around Littleton, one in Franklin County, and the third in the Connecticut River Valley section of Hampshire County. In addition there is the Worcester County Association, county wide in the territory it covers, supported partially by county funds, and under the direct supervision of the officials of the farm bureau. Very little work has been done with the latter two. A number of farm visits have been made to members of the Franklin County Association for the purpose of procuring record cows for the fair exhibit, and work of the same character was done with the Hampshire County Association in the interest of the reorganization of the association, so as to put it on a firmer basis. In both of these associations there is a call for having the privilege of advanced registry work done by the association testers. As there has been no county agent operating in Middlesex County, more work has been done with the Littleton Association. Quarterly meetings of this association have been attended regularly, and four new herds with a total of 75 cows have been added to the association. The total number of cows on test in this association is 418. Last year's records for the three associations are to be combined with material from the fair exhibit in the form of an advanced publication on this work. Meetings have been held in three localities — Munson, Billerica and Ware — in the interest of record association work. In the two latter sections considerable interest was shown, but more local work must be done in order to get enough cows in line to form a successful association. An attempt will be made during the coming year to do more work in these two sections and at least two sections in the western part of the State.

Lectures.

A number of lectures were given before granges and other farmers' organizations. A number of these were given at the request of the various county agents, and the remainder on the

direct call of the organization holding the meeting. A statement of the attendance at these meetings is given later in this report.

Boys' Stock Judging Contests.

These contests were held under the supervision of some one from the office at fourteen different fairs during the past year. At two other fairs local conditions forced the canceling of the contests that had been planned. The total number of entries in the fourteen contests was 244, 124 different contestants taking part. A number of boys entered in more than one, and a few in as many as five different contests. At the junior judging contest at Springfield, at the National Dairy Show, 35 boys and 1 girl were entered from this State. The Massachusetts entries took 9 of the 19 prizes offered in competition with the 64 other contestants from 7 other States. Eight pure-bred dairy bull calves and one cash prize were awarded to the successful Massachusetts contestants. This work is one of the most interesting and encouraging lines of work undertaken by this office, and in planning for the coming year an attempt will be made to increase the number and value of these contests by offering supervision over the contest to all local fairs that care to undertake this work, and by attempting to give some training along this line to local groups prior to the fair season. To further the latter a list has been kept of the names, ages and addresses of all of those taking part in the contests this past year, these to be used as nuclei around which the local groups will be formed.

Co-operative Bull Association.

A new line of work begun in this State the past year was the organization of a co-operative bull association at Winchendon. This work was done in co-operation with the dairy division of the United States Department of Agriculture. The dairy farmers making up the association decided on the Guernsey as the breed to be handled by their organization, and two young bulls, good individuals, were purchased. It is hoped that this association will be enlarged by the addition of more breeding blocks. The progress of this association will be closely

watched, with the view to furnishing any necessary help and ascertaining the possibilities of further work along this line in other sections of this State.

Fair Demonstration Work.

Fair demonstration work this past year consisted in attending eight different fairs with the college exhibit. The animal husbandry section of this exhibit was made up of dairy cows having production records, loaned to the exhibit and procured largely through the co-operation of the agricultural agents operating in the different counties. An attempt was made to get those persons interested in dairy cows to place the cows in the exhibit on the basis of what it was thought they would produce. The records of the cows were posted twice daily, and a short talk was given on the value of keeping individual records. There were 2,162 persons who were interested enough in the exhibit to record their placings of the cows. This was a relatively small percentage of those who passed through the exhibit, but it was made up largely of dairy cattle owners. It is firmly believed that this exhibit proved of very great value in emphasizing the importance of knowing the individual production of the cows in the dairy herd, and that as a result of the exhibit more cows have been put on record in the localities visited.

Miscellaneous Visits.

Under this project are classed visits made to pure-bred dairy farms, with a view to getting acquainted with the breeders, sales of pure-bred live stock attended, judging work at fairs, farm visits made on request and not covered by some other project, and meetings attended where no part was taken in the program.

Statistics.

Extension schools: —	
Number,	6
Lectures,	44
Attendance,	1,195
Milk show,	1
Number of milk producers to whom records have been sent,	90

Single lectures: —	
Number,	38
Attendance,	3,106
Stock judging contests: —	
Number,	14
Entries,	244
Co-operative bull association organized,	1
Fair exhibits: —	
Number,	8
Placings on cows recorded,	2,162
Meetings and conferences attended,	22
Farm visits made,	160
Live stock judging (fairs),	6
Publications prepared,	1

REPORT OF WORK ON FARM MANAGEMENT DEMONSTRATIONS.

Farm management demonstrations are carried on in Massachusetts, with two objects in view: —

1. To furnish the farmer with a simple workable method by which he can sum up and analyze his farm business, and to show him how to use the method.

2. To demonstrate to the farmer the conditions which influence success in farming, and help him in reorganizing his business for greater profits.

In order to bring about the first object we have employed during the year the following means: —

The Farm Record Book. — This book was published by the Extension Service in January, and it is now being used generally through the State in keeping a record of the farm business. In the farm management demonstration areas the book is being used more than in other sections of the State because of our work with the individuals in the areas. We are finding about 50 per cent. of the books being used the first year. Through the county agents and the agricultural schools farm records are being started with other farmers throughout the State. We placed the books with a large number of farmers through our fair circuit work, and also as a result of mail requests.

Farmers' Bulletin No. 661. — This bulletin has been used in some areas in showing farmers how to figure their year's business. It has been very effective in this connection.

Meetings — Meetings have been held in various sections of the State on request, to show methods of summing up and analyzing the farm business. These meetings have been the least productive in securing results of all methods used. We are attempting to introduce a new method this year which we believe will be more productive. This method will be outlined later in the report.

In order to bring about the second object of our work — to demonstrate conditions which influence success in farming — we have employed the following means: —

General Meetings. — Meetings of groups of farmers in our areas and in other parts of the State have been held at which results from the areas were presented. A general discussion follows the presentation of the facts, and so opportunity is given to bring out the importance of maintaining a well-balanced farm. One very effective means used to induce farmers to really study the effect of the different factors on profits has been our guessing charts and slides. Individual farms are compared with the average in regard to the size, diversity, crop yield and stock production factors, and the audience is asked to estimate the labor incomes of the individual. In order to estimate intelligently it is necessary for them to study the importance of the different factors. On the fair circuit this same method has been used, but with less satisfaction than at other meetings.

We now have a lantern-slide lecture made up of charts and photographs, bringing out important conditions and methods of improvement. The slides are very satisfactory in keeping the farmers interested and in driving home the facts one presents.

Area Reports returned in Person. — In our demonstration areas the return of figures to the individual farmers in the form of area reports has been productive of good results. The more simple our reports the better the results. This is the one outstanding fact in regard to area reports this year. An area report of the general type of the one used in Norfolk County is more productive of results than one of the type used in Essex County. Area reports are still in the experimental stage, and it is not proved that we have the right type yet.

The county agents and agricultural instructors have done some work in bringing about the two objects outlined, outside of the demonstration areas. The two means employed have been meetings and introduction of the farm record book. This part of the work has not been developed as well as it might be, and it is hoped that more and better organized follow-up work may be done during the coming year. This is the next big step in our work.

Work in Each Area.

Bristol County. — This demonstration is now in its third year. During the year fifty records for the second year were returned and forty-five records for the third year were taken. These records have been worked up into an area report which is now ready to be returned. The demonstration is producing results in this county. One farmer's record showed that he had a labor bill out of proportion to the business done. Since the first year he has decreased his labor expense which has resulted in a higher labor income. Another farmer had a rather small business and feed costs were too high. The owner built a silo to decrease his feed bill and has increased the size of his business considerably. His labor income was much larger last year than for previous years. Low producing stock was one weak factor on a third farm. This man has purchased a pure-bred bull from another farmer in the section and is now breeding up his stock. Thirty men are keeping farm accounts in this area as a result of the work. Numerous other improvements as a result of the work in this area might be given. The fine progress of the work in this county is largely due to the work of the county agent who has followed up the demonstrations through the year.

A second area was started in co-operation with an agricultural instructor in North Easton, Bristol County. Thirty records were returned in this area. The work was discontinued because the agricultural instructor lacked time to devote to the work.

Berkshire County. — No area has been started in this county, although one meeting to arouse interest has been held. We are postponing a start in this county until sufficient interest has been aroused. The work is to be presented in two or three

other towns, after which we expect to make a start wherever the largest amount of interest is shown.

Essex County. — Second-year records on sixty-eight farms were ready to be returned in person during December, and, up to December 1, six records for the third year had been obtained. Eighteen second-year records were obtained during December of last year and January and February of this year. Nineteen account books were started in this area. So far this demonstration has been the most unsatisfactory one in the State. The reasons for this are (1) the area was started without preliminary work or request from the farmers, (2) very little follow-up work was done, and (3) records were taken and returned by different men. Some records were taken by men who were immature and did not understand the proper methods. When work was started in this county there was no county agent; now that one is on the ground and at work we hope to change the feelings of the farmers toward the work through more efficient follow-up work.

Franklin County. — During the year fifty-four tobacco and onion records were returned by the county agent. The work was followed up during the summer, and new records will be obtained in December, 1916, for that year's business. Twenty-six farm record books are being used in this county.

Hampden County. — Forty-four second-year records were returned in this area by Agricultural Instructor Abbott, and thirty-seven third-year records were obtained. A considerable amount of follow-up work has been done during the year. The farm record books were not published in time for use in this area, so there are no figures on the number keeping farm accounts. One prominent farmer in this area stated that "If no further work was done in this area, the work done now would be felt for twenty years." The changing of agricultural instructors in the school has handicapped the work considerably.

In the Southwick tobacco area of this county forty-four records were returned by the county agent. This area was discontinued because of lack of interest in the section.

Hampshire County. — Eighty-three tobacco and onion records were returned in this county during the spring of 1916. It was decided to discontinue this area because the area in Franklin

County covers the same type of business. This fall a new area was started in South Amherst, a general farming section. A preliminary meeting was held in the town to arouse interest. At this meeting a committee of farmers was appointed to canvass the town in company with County Agent MacDougall. They succeeded in signing up thirty-two farmers. We hope to bring this number up to forty when the farm record books are started in January. We plan to start farm record books with each farmer, he to keep them during the year, and then sum up his year's business at the close of the year. Records will then be obtained from the books and worked up into an area report. This area is being started subsequent to a definite request from the farmers.

Middlesex County. — Records for the second year on thirty-five farms were taken in this area in January. They were worked up into an area report in February and returned during the spring. Twenty-three farm record books were started in this area and sixteen outside the area. Of the twenty-three books started, twelve were in use July 1. This work is being done in co-operation with an agricultural instructor.

Norfolk County. — This area was started after a preliminary meeting in the section. A committee of farmers canvassed the section and found twenty-two men ready to come into the demonstration. Records were taken during January and returned during November, at which time new records for 1916 were obtained and seventeen farm record books were started. Eight farm record books were started outside the area. None of the original group refused to come in the second year. The county agent, who was only lukewarm at first, is now canvassing another town in his county, with the idea of bringing the number up to forty.

Plymouth County. — During the year a poultry area was started in this county and thirty-three records were taken. This work was undertaken without a preliminary campaign. The records are now being worked up for return this spring. The county agent co-operates in this work. Twelve farm record books have been placed outside this area.

Worcester County. — Thirty-five records were returned in Bolton area, in Worcester County, last spring and twenty-one

farm accounts were started. This was the second year for this area. Work was discontinued largely because of the fact that there was one other area in the county, — the Sterling area. Our two years' work in this area was productive of results in showing the farmers how to sum up and analyze their farm business, and also in bringing to their attention some of the conditions which influence profits in farming.

Sterling Area. — Thirty-nine records for the third year's business were returned in this area and thirty-seven records were taken for the fourth year. Seventy-five per cent. of the men we had records from are keeping farm accounts. In this area nineteen farmers out of the thirty-seven records obtained figured their own records through the use of Farmers' Bulletin No. 661. The plan of action was to have the farmers come to central places in small groups of from six to ten to figure their records. The first meeting was at the house of one of the farmers. Four men came in that afternoon and figured their own labor incomes with the use of the blanks. They showed great interest in doing it themselves and seeing the method and results obtained. During the week, seventeen of the thirty-seven came to these local meetings. They were very much interested in comparing one year's record with another and seeing why their labor incomes went up or down. They are profiting by this comparison. Good results have been secured in this area. One farmer who needed more land and better stock is now renting an adjacent farm, has purchased a pure-bred bull and two pure-bred cows, has joined a cow-testing association and put up a 16 by 30 foot silo. Another who was going behind selling butter is now selling market milk again. Another has increased his business with more stock and put up a silo. A large number who kept no accounts, or at best a very meager record, are now keeping a complete record of their year's business through the use of our farm record book.

Work outside of Areas. — During the fall, eight fairs located in seven different counties were covered in connection with the regular college exhibit. Charts showing conditions influencing success in farming were exhibited, as was also the new farm record book. About 100 books were sold to farmers during the season.

An extension bulletin explaining the farm management demonstration work in Massachusetts, and giving the results of the work, has been prepared. An edition of 3,000 copies has been exhausted, and a new edition of 4,000 more will soon be ready for distribution. Statistics upon the work are given at the close of the report.

A lantern-slide lecture comprised of fifty slides has been prepared for use by the farm management demonstrator and the county agents. This lecture gives results of the work in the areas, and shows how the work is conducted.

Future Plans for the Work.

The old areas will be carried through under the following plan: farm record books will be used and the farmers will be brought together in small groups to figure up their year's business. Where the individuals are not using the record book, Farmers' Bulletin No. 661 will be used to show farmers how to sum up their year's business. Area reports will be returned as in former years, and the farmer will be given a comparison of one year's business with another.

With new areas the following procedure will be used: —

1. Maintenance of only one area in a county.

2. Preliminary meetings to arouse interest will be held and a large amount of publicity work done before starting the demonstration, and areas will be started only where sufficient interest is shown.

3. Preliminary meetings will be held to acquaint the farmers with the method of figuring labor incomes, and to show how the farm record book is used.

4. The proper type of farm record books will be placed with the farmers through personal visits, taking their inventories and bringing their farm record books up to date. Where farmers have records that are suitable, which are now being kept, new methods will not be introduced unless this is requested.

5. When necessary, follow-up work will be done, visits being made to the farmers during the year to help them in keeping their figures and in making any changes in their farm business which seem to be desirable. Follow-up letters will be used at

times during the year when the farmers are most apt to discontinue their records because of other duties.

6. At the end of the year the farmers will be brought together to sum up their records from their farm record books.

7. Individual records will be worked up into the area report and returned to the farmers in person.

8. New record books will be started with the farmers again for the next year.

Future Work outside Demonstration Areas.

The demonstrator purposes to put in one day with each extension school through the winter, giving a demonstration and a lecture. The demonstration will consist of instruction as to how to sum up and analyze the farm business. Records of a year's business on successful farms will be used for this demonstration. The lecture will consist of a presentation of the results from the farm management demonstration area in the county, using the lantern slides. Where calls for day meetings of farmers' clubs, etc., are received the same combination of a demonstration and lecture as outlined above will be given. Work of this type will create a demand for farm management demonstrations.

Statistics.

	Farm Management Demonstrations.	County Agents.	Agricultural Instructors.	Total.
Records taken,	78	105	71	254
Records returned,	136	344	60	640
Farm accounts started and farmers assisted,	220	221	21	326
Follow-up work,	43	115	128	286
Lectures,	24	–	–	–
Attendance,	771	–	–	–
Conferences,	27	–	–	–
Fairs,	8	–	–	–
Letters written,	432	–	–	–
Area reports,	11	–	–	–
Press articles,	1	–	–	–
Extension bulletin,	1	–	–	–

REPORT ON EXTENSION WORK IN POULTRY HUSBANDRY.

Extension work in poultry husbandry has been carried on since the organization of the poultry department. It is only during the past year, however, that a specialist has devoted his full time to this line of work. The demand for demonstrations and lectures has been so great, however, that other members of the poultry department have been called upon to assist. Practically all of the work done has been of a co-operative nature. Farm bureaus, granges, poultry associations, men's clubs and women's clubs have been assisted in various ways toward a better understanding of the poultry industry.

Demonstrations and Lectures.

Practically all work done in the field may be considered as demonstration work, for its first purpose has been to show the best known methods of carrying on a poultry-keeping business both as a specialized business and as a branch of some other interest. The equipment used for this purpose consists of models, charts, lantern slides, etc., all of which are based on actual results of work done in our own or other experiment stations. The results of successful poultrymen have also been used to a greater or less degree.

The demand for this line of work has at all times exceeded the possible time the department could allot to it. The following single lectures and demonstrations include only those given before farm bureau meetings, poultry associations, clubs of various kinds, granges, etc.: number of lectures, 127; attendance, 8,231.

Conferences.

In co-operation with the county farm bureaus conferences have been held with poultrymen on local poultry plants. A great deal has been accomplished through this work. The plan has been to arrange a meeting of all poultrymen in a district upon one of their poultry farms. After inspecting the plant those in attendance would present questions and problems to the extension specialist, he having first opened the discussion, using the farm visited as a basis. This work has been of value

because the methods discussed have been right at hand, and could be seen in actual practice. On most farms visited records had been kept and were used in the discussions.

A limited amount of conference work has been done with individual poultrymen having specific problems. In this connection several poultrymen are co-operating with the department in breeding for increased production. Number of conferences, 98; attendance, 364.

Testing for White Diarrhœa.

This project has been carried out in co-operation with the department of veterinary science. The extension specialist arranged for and collected the necessary blood samples. The veterinary department carried out the laboratory work with the samples. Two days of the extension specialist's time were devoted to this work in each week until the last of May. The entire work was then turned over to the veterinary department, which has carried it on since that time. Reports of this work issued by the experiment station have shown its value. It need only be said here that thousands of dollars have been saved to the poultrymen by ridding the flocks of infected breeding stock. The following figures are from the work done to May 30, 1916: flocks tested, 38, — females, 6,115; males, 261.

Extension Schools.

Poultry courses were given in nine agricultural extension schools and one community planning school. The entire work of each school consisted of five days. In five of the schools the study of poultry keeping divided the week's work with horticulture. In two schools it was given throughout the entire week, and in the community planning school for but one day. The demand for this work has been steadily increasing. The reason for this is that these schools come at a season when the farmers and poultrymen are not busy and can take the largest possible advantage of the courses given. The school further permits those who have special problems to discuss them with the instructor between periods. The following figures include the lectures given at all schools together with the total attendance: number of schools, 10; lectures given, 57; attendance, 400.

Farm Visits.

Both successful and unsuccessful poultry farms have been visited, in many cases to give advice, and in other cases to gather information which might be of value to others. Farms visited, 20.

Field Meets.

During the past year the department has assisted by furnishing demonstrations and lectures at several field meets. Important meets have been those held by the Essex County Agricultural School, the Plymouth County Farm Bureau and the Hampden County Improvement League. Field meets, 4; demonstrations, 7; attendance, 500.

Exhibits.

The department has put on a number of educational exhibits during the past year. They include those at poultry shows, agricultural fairs in the field, for the short course and poultry convention at the college.

Probably no other line of work has done more to show the value of proper methods than our exhibits. Throughout the year we have specialized on factors influencing production. For this purpose live fowls with pedigrees have been shown, being grouped in pairs, such as good and poor producers; broody and non-broody; early and late maturity; high and low rate of production; good and poor vigor; early and late hatching; high and low fertility, etc. Model houses and equipment, together with methods of feeding, have been shown.

There is a greater demand for this line of work than the department can at present care for. The policy has been to give a series of lectures and demonstrations with the exhibit. Educational exhibits, 14; demonstrations, 25; attendance, 22,750.

Boys' and Girls' Poultry Club.

The organization of this work has been done through the State supervisor, the details and technique by the poultry department. That great interest has been taken in this work

has been demonstrated by the increased enrollment each year. The problem of maintaining it properly, giving it the necessary time and attention, faces the department. The point has now been reached where, in order to do efficient work, it will be necessary to employ a specialist for this line of work. Such a worker would be able to give his undivided attention to the many details connected with it.

Conferences and Visitors.

Perhaps one of the greatest problems, and one seldom considered, is how to care for the increasing number of visitors to the poultry department. These people come from all sections of the State to get first-hand information on various subjects pertaining to poultry keeping, and to see the methods and equipment used by the department in actual operation.

Many others come for conferences concerning specific problems of equipment or management. All of this work requires a great deal of time and attention, but represents a large part of the work in assisting the poultry interests of the State. Conferences and visitors, 1,575.

Correspondence and Circulars.

Considerable time has been spent during the year in answering correspondence and preparing circulars of information. Circulars prepared have had for this purpose complete information on certain subjects which it would be impossible to give through correspondence without considerable increase in assistance. The following summary covers that which might be termed office work: —

Extension letters,	6,244
Bulletins sent out,	806
Circular letters sent out,	875
Programs prepared and sent out,	12,000
Blue prints sent out,	342

Publications Prepared.

1. Revision of bulletin for boys' and girls' club.
2. Monographs, as follows: —

Blood Clots in Eggs.
Selecting a Breed.
Causes of Poor Hatches.
Amateur Poultry Keepers.
Preserving Eggs.
Egg-eating Habit.
Home-made Mixtures.
Colds and Roup.
Duck Raising.
Leg Weakness.
Turkey Raising.
Feather Eating and Crop Bound.
Feeding the Layers.
Feeding the Breeders.
Shell-less Eggs.
White Diarrhœa.
Losses from Tainted Ground and Poor Management.

Correspondence Course.

Various parts of the poultry course have been revised and brought up to date. A special effort was made during the year to organize those taking the course into groups, which met and discussed the various lessons from time to time, the advantage of this being that it was possible for a member of the department to meet with the group at times and go over the work with them.

Students enrolled in correspondence course, 282.

Miscellaneous Extension Work.

Meeting of investigators and instructors in poultry at Columbus, Ohio, five days.

Lecture course, Boston Chamber of Commerce, 7 lectures, 1,750 in attendance.

Poultry shows judged, 5.

REPORT ON EXTENSION WORK IN DAIRYING.

Below you will find a brief report of the extension work done by the dairy department, Dec. 1, 1915, to Nov. 30, 1916.

Probably one of the largest pieces of work done this year was in connection with the National Dairy Show: —

First. — In helping to secure the National Dairy Show for Springfield.

Second. — In aiding in developing this show.

Third. — In taking charge of the exhibits from the agricultural colleges as a whole, and also in planning and caring for the exhibit from this college at the show.

The head of the department went to Chicago with the Eastern States people, and appeared before the National Dairy

Show directors, presenting to them the fact that the bringing of the National Dairy Show to Springfield in 1916 would be of material help to dairy interests in the east, and would fit in with our educational work as it is being carried on.

In advertising this show the head of the department lectured before the State Dairymen's Associations of New Hampshire, Vermont, Massachusetts and Connecticut, and also at the farmers' weeks in New Hampshire, Maine and Massachusetts, and explained to those present what the National Dairy Show is, what it stands for, and what benefits they might expect to derive from attending.

The head of the department was superintendent of the colleges' exhibits and conventions at the National Dairy Show, and also called together the representatives of New England colleges and secured their co-operation in putting on a non-competitive exhibit, planning the work so that each college would be represented by a specific piece of work. This enabled each one to put on a better exhibit than otherwise, and there was no duplication of the work.

Another phase of our work is the milk shows. Heretofore this has been our most important work, and we still feel that it occupies this position. The large milk show, in Boston, held in conjunction with the State Board of Agriculture's winter meeting last winter, had 325 samples of milk and cream and 19 samples of butter. This was the largest show yet held in Massachusetts, and one of the largest, if not the largest, in the United States. The milk inspectors were so interested in this work that through their efforts eighteen silver cups and two medals were offered as prizes for milk coming from different parts of the State; ribbons and diplomas were also awarded.

The second milk show was held at the college during farmers' week, and there were over 100 milk and cream samples and 19 butter samples entered. This is the largest show yet held here. We also had charge of the milk samples for a milk show (the second held at the Fitchburg Fair) under the auspices of the local milk inspector. The interest in this show was very great among the local people.

About the 20th of November we received a request to help with a milk show organized and worked up by local milkmen,

and held in conjunction with a poultry show, in Taunton, Mass. We expect to have at least 60 samples. This show will be a big factor in presenting certain facts to the local consuming public. People in general are becoming more interested in clean milk, and there is great need for this kind of work.

Feeling that the government score card for milk and cream did not quite fit our general market-milk conditions in Massachusetts, the head of the dairy department met a committee from the Massachusetts State Board of Agriculture and the Massachusetts Milk Inspectors' Association, and we have prepared a score card that we feel will more nearly fit our needs. This score card will be used at our next show in Springfield.

From the interest taken in the show work, and from inquiries that have come to the department for extra scoring of milk and cream, we feel that it would be a good plan to establish a quarterly scoring. These scorings could take place as follows: one scoring for the annual milk show held in January, one scoring for farmers' week, one scoring in the summer, and one scoring in the fall (the one in the fall, possibly, coming at the same time as the Eastern States Agricultural Exposition in Springfield). Awards could be made on the basis of the year's work if desirable. I have had this proposition before the milk inspectors, who heartily approve of the plan. The milk inspectors are a big factor in the success of the shows, as they come in personal contact with the men who send in milk for scoring at these shows. We send the inspector a copy of the score cards, and he in turn talks with each man regarding his score. In this way we find that this not only interests the man himself, but also the milk inspector.

We have sent out about 12,000 announcements and circular letters relative to the milk shows. We have written 1,500 letters in direct answer to inquiries. The correspondence relative to the milk show work is very heavy.

The cost of the Boston milk show, last winter, was $1,008.15, and the cost of the farmers' week show, last spring, was approximately $300.

During the past year we have co-operated with the Dairy Bureau of the State Board of Agriculture, the Massachusetts Milk Inspectors' Association, the Massachusetts Dairymen's

Association and the county farm bureaus. The State Board of Agriculture and the Massachusetts Dairymen's Association have contributed labor and financial aid. The milk inspectors have co-operated in helping to awaken interest among the producers. The county farm bureaus have made it possible for us to meet the farmers' interest.

One of the men in the department spent considerable time at the agricultural fairs.

We have given advice at conferences and to individuals relative to the location and plans for creameries and milk plants and for equipment. At least five of the State institutions have come to us for advice on milk-handling equipment.

REPORT ON EXTENSION WORK IN BEEKEEPING.

The following extension work in beekeeping was carried out during the year.

Lectures.

Twelve lectures have been given during the year, eleven by the undersigned and one by the superintendent of the apiary. These lectures were given in the following places: South Hadley, Southborough, North Orange, West Mansfield, West Boylston, Northampton, Dalton, Springfield, Mass.; New Brunswick, N. J.; Storrs, Conn.; Altamont, N. Y.; Fort Edward, N. Y.

In addition we have had a great number of beekeepers, and others interested in bees, call at the office and at the apiary for special information. With the additional number this year it has been necessary to start a record which will take the form of a register. At times it has been questionable whether the number of visitors does not materially interfere with the routine work of the bee yard.

The department arranged for the sequential meetings for August, a part of which the writer attended. In addition there were two other meetings arranged for. All of these circuit meetings were attended by Mr. C. P. Dadant, editor of the "American Bee Journal," Hamilton, Ill. The other meetings attended by Mr. Dadant were those of the New Jersey Beekeepers' Association and the Vermont Beekeepers' Association,

Middlebury. The success of this series of meetings demonstrates the desirability of circuiting prominent authorities not only for this State, but generally with the association in eastern United States.

The writer has enjoyed the co-operation of beekeepers' associations, farmers' institutes, farm bureaus, State Board of Agriculture and more private organizations.

The rendering of beeswax has continued on a large scale. In this work the college serves as a central rendering station, charging a nominal fee of 5 cents per pound for each pound of product obtained. Shipments are received from all quarters. This work of rendering also furnishes material for experimental data.

Needs and proposed plans for the future have been outlined otherwise and in the form of projects, especially the one under date of July 2, 1914, which calls attention to means whereby work of extension nature can best be begun and worked out agreeably to the needs of the beekeepers. The writer still petitions along these lines.

REPORT ON EXTENSION WORK IN RURAL CIVIC PLANNING.

Rural civic planning, as the name implies, has to do primarily with the physical development of public tracts of land in towns and villages, such as the design, grading and planting of school grounds, town parks or other public reservations, the grading, construction and planting of streets within the town, the design and location of street accessories, such as lights, street signs, etc., the country road and roadside, its construction and care, the redesigning and planting of cemeteries, railway station grounds, trolley waiting stations and similar public utilities. It is also understood to include advice relative to sanitation and public health, these pertaining especially to problems of sewage and garbage disposal, of housing and of water supply.

General Statement.

The conditions under which work has been undertaken by this department have been adhered to strictly: (1) the special desire of the college to assist the small *rural* communities which

will always be given the preference; (2) the work is confined strictly to public enterprises and no work is undertaken for individuals; (3) all expenses for travel and for drafting of plans are charged to the communities or organizations served, but no charge is made for services of men sent from the regular college staff; (4) no work of any kind is undertaken on projects which can and should be handled by professional landscape gardeners or engineers, in such cases the college advising to that effect and supplying a list of reputable professional men upon request;[1] (5) as it is impossible to do all the work needed in the State the college does not engage to do more than can be well handled with the men and equipment at its command.

Work of the Year.

Two particular lines of work have been emphasized in the past nine months, namely: —

(*a*) Visits and general surveys of many small towns in the State, later followed by general reports, including specific recommendations for definite projects, as mentioned above. Due to the fact that every town has its own specific problems, a large amount of study was necessary in each case to foresee as far as possible the future needs of these villages.

(*b*) Assistance has been rendered public institutions in the State, particularly hospitals, asylums, county agricultural schools, and the like, in a co-operative way in the solution of their particular development problems, which include grading, layout of roads and walks, location of buildings and service sections, planting plans and details of development of the various tracts in question.

On Feb. 15, 1916, the undersigned was appointed as extension instructor in civic improvement in charge of this work, and unfinished work was developed so far as possible and new projects immediately undertaken. The work of the past nine months can be divided as follows: —

1. Answering requests for assistance, including visits, preliminary surveys, preliminary and final reports, lectures, con-

[1] After an address recently delivered by the extension specialist before the Boston Chapter of the American Society of Landscape Architects, this organization as a body voted unanimously to co-operate with the college in furthering this phase of the Extension Service.

ferences, sketches, detailed plans, estimates and specifications and supervision of construction.

2. Follow-up work, whereby the construction is checked and efforts stimulated, revived and redirected in a manner not possible in a strictly professional office.

3. Bringing to as many people as possible throughout the State fundamental ideals and principles by means of lectures, leaflets, bulletins, exhibitions of typical plans, models, demonstrations and the organization and correlation of existing and proposed agencies within the town, looking toward the unification of all efforts.

The department has particularly co-operated with local agricultural instructors, school superintendents and school boards, village improvement societies and town planning boards, boards of trade, town selectmen, women's clubs, churches and other organizations within the communities, the State Board of Education and the county agents in the various counties.

Requests have been received from thirty-three towns which have been visited and for which definite reports and plans have been prepared. The following is the list: Amherst, Bourne, Concord, Grafton, Groton, Groveland, Harvard, Hatfield, Hathorne, Hubbardston, Lanesborough, Littleton, Medfield, Millis, Montague, North Abington, North Amherst, North Adams, Pepperell, Petersham, Pigeon Cove, Plainfield, Shelburne, Southampton, South Amherst, South Ashburnham, Sterling, Three Rivers, Walpole, Westborough, Westminster, Williamsburg, Worcester.

The interest displayed in this work may be judged when it is stated that in support of the projects, covering the cost of plans, travel, etc., the various communities of organizations benefited thereby will have paid over $1,000 during the nine months closing November 30. Definite construction work is under way in many of the towns, and a great deal more will be taken up during the coming spring and summer, when it is hoped labor conditions will be more settled and less difficulty be encountered in carrying out the work. More than 100 separate plans have either been completed or are at present in process of development.

For the Danvers State Hospital at Hathorne and for the

Westborough State Hospital at Westborough plans and reports were prepared, and for the Norfolk County Agricultural School at Walpole and the Essex Agricultural School at Hathorne plans and reports submitted have been followed by definite construction.

Under the head of miscellaneous work for the past nine months should be listed several circulars and magazine articles, miscellaneous lectures in various parts of the State given upon request, courses offered in the summer school, a civic improvement exhibit in connection with the floricultural show, a civic improvement exhibition in St. Louis at the Missouri Botanical Garden, a similar exhibit in both the University of Nebraska and the Iowa State College, and particular attention paid to the preparing of plans and models for exhibition work in a traveling exhibit later to be sent to the libraries of the State.

Plans for the Future.

Proposed activities for the coming year include the preparation of plans and reports for the various towns for which improvements are at present under consideration. Further work of this kind will be taken up and pushed to the exclusion of other projects. It is our desire, also, to take up further work with the public institutions of the State, and undoubtedly a large amount of construction work will be carried out during the coming year on various projects for which plans have but recently been completed. A number of pamphlets and bulletins will also be prepared, and public lectures will be given throughout the State wherever there seems a need for this work.

Summary of Work done.

1. Surveys prepared of various public tracts of land in the following towns: Amherst, Concord, Grafton, Groveland, Hathorne, Hubbardston, Medfield, Montague, North Abington, North Adams, North Amherst, Pepperell, Petersham, Pigeon Cove, Shelburne, Southampton, South Ashburnham, Three Rivers, Walpole, Westborough.

2. Preliminary plans, followed by grading, construction or planting plans, prepared for the following towns: Amherst,

Concord, Grafton, Groton, Groveland, Hubbardston, Medfield, Montague, North Abington, North Adams, North Amherst, Pepperell, Petersham, Pigeon Cove, Shelburne, Southampton, South Ashburnham, Sterling, Three Rivers, Walpole, Westborough.

3. Recommendations for town development in the form of construction, grading, planting or otherwise improving streets and public tracts within the towns carried out or in process of construction in the following towns: Grafton, Groton, Groveland, Hadley, Hubbardston, Medfield, Montague, Pigeon Cove, Russell, Southampton, South Ashburnham, Sterling, Three Rivers, Walpole, Westborough.

4. Conferences relative to the Extension Service in civic improvement in the following towns, with local agricultural instructors, school superintendents and school boards, village improvement societies and town planning boards, boards of trade, town selectmen, members of the park board, women's clubs, churches and other organizations within the communities, the grange, the State Board of Education, the county agricultural schools and the county agents in the various counties: Amherst, Brockton, Concord, Dedham, Grafton, Groton, Groveland, Hadley, Harvard, Hatfield, Hathorne, Hubbardston, Lanesborough, Medfield, Millis, Montague, North Abington, North Adams, Northampton, Pepperell, Petersham, Pigeon Cove, Plainfield, Sandwich, Segreganset, Shelburne, South Amherst, Southampton, South Ashburnham, Sterling, Three Rivers, Walpole, Westborough, Westminster, Williamsburg, Worcester.

5. Lectures delivered by the extension specialist upon town improvement in the following towns: Amherst (4 lectures), Baldwinsville, Bourne, Grafton, Groton, Groveland, Harvard, Littleton, Medfield, Monson, Pepperell, Pigeon Cove, Plainfield, South Amherst, Southampton, South Ashburnham, Springfield, Sutton, Tyringham, Westminster, Worcester.

6. General town improvement reports prepared by the extension specialist for the following towns: Grafton, Groton, Groveland, Harvard, Pepperell, South Ashburnham.

REPORT ON EXTENSION WORK IN CO-OPERATION AND MARKETING.

The work of co-operative organization and marketing, which is now being carried on by the writer, was started about three years ago, and since then has grown very rapidly. During the past year thirteen groups have been brought together to purchase raw materials and market their various products, such as milk, blueberries, strawberries and maple sugar. In the following table the organizations which have been incorporated under the laws of the State are separated from those not incorporated: —

	Not incorporated.	Incorporated.
Milk,	4	2
Blueberries,	1	1
Strawberries,	-	1
Creameries,	-	2
Maple sugar,	1	-
Supply associations,	-	1

The writer took this work up on Feb. 8, 1916, and for the first few months put in most of his time visiting those organizations which were already formed, getting acquainted with their managers, officers, members, etc., and finding out what they had been doing in the previous years. In some cases he found that the organizations were not carrying on their business along the principles which would lead to success, and advice was given so that the business principles were changed. For instance, the writer visited one organization the latter part of May, and found that the manager had done very little business, chiefly because he did not know how to get hold of the members and put a business proposition up to them. The ground was gone over thoroughly, and after explaining many of the different ways of these organizations, telling experiences which other associations had received, the manager has reported recently that their business increased about 3,000 per cent. during the following six months.

Besides the work in co-operative purchasing, the extension specialist has also aided those organizations which called him to assist in grading their product, labeling and advertising, with the result that from figures collected the producers have received more money for their product than in past seasons, and the consumers have received their product in better condition and fresher than in the past.

A campaign has been carried on with the milk producers of the State, working towards a State-wide co-operative organization. It was felt that the milk producers were not receiving a fair price for their product, and, in spite of the many protests, the distributors were not willing to pay higher prices until obliged to do so. The farmers of the State realized that individual effort would not lead to better prices, with the result that the extension specialist was called in and organized farmers in six different sections, and a fair price was received for milk. These organizations have been formed along co-operative lines, and two have been incorporated under chapter 125 of the laws of Massachusetts.

While the aim of these organizations has been partly to secure a better price for their product, a movement is now on foot to encourage the formation of cow-testing associations and breeders' organizations, the purchasing of farm supplies and equipment, and putting on the market a higher grade product than in the past. These organizations also have in mind the advertising of their product, showing the food value as compared with other foods, with the hope of increasing the consumption of milk, and bringing back to Massachusetts the number of cows which it has had in former years.

It has been felt for many years that the grading and distributing of market-garden crops, such as lettuce, cucumbers and tomatoes, has been neglected in the State. This has resulted in a careful study of the grading and distribution of these crops, mainly through the chamber of commerce, wholesale and retail trade, and, to a certain extent, through the consumer.

The work has also consisted of lectures before local and pomona granges, community schools, county agricultural schools, meetings called by county agents, chambers of com-

merce, regular classes in agricultural economics, summer school classes, farmers' co-operative exchanges, farmers' week audiences on special days at the college, as Polish farmers' day, and before the graduate school, poultry conventions and various other organizations. At these meetings various subjects have been discussed, among these co-operative marketing, co-operative purchasing, better methods of marketing, marketing by parcel post, better business methods, and lessons to be drawn from what other organizations are doing.

Conferences have been held with farmers individually and collectively, various wholesalers, jobbers and retailers of farm products, county agents, government agents, managers of co-operative exchanges and others, all of which were held tending to the betterment of the agricultural industry.

While there have been, as stated before, thirteen co-operative organizations formed this past year, the extension specialist has felt that it would be much better to put in as much time as possible building up those organizations already formed and putting them on a permanent basis.

NEEDS AND RECOMMENDATIONS.

There are many problems which we are now facing, and will have to face in the near future. Among these are —

1. Financial Support.

One of the most important of these problems is adequate financial support for extension work. The Legislature of 1912 passed an act providing an appropriation for extension work of $50,000 annually for a period of five years. We have just completed the third year's work under this appropriation, and we face the situation of having to meet greatly increased demands for the work with a fixed and inelastic appropriation.

With only 24 per cent. of our land under cultivation; with a population 92 per cent. of which are non-producers of food products; with a smaller number of farms than in 1900; with an ever-increasing growth of industrial centers; with statistics which show that we produce only about one-fifth of the poultry products consumed, about one-half of our dairy products, about one-fourth to one-half of our fruits, market-garden produce, potatoes, etc.; that we now bring into the State about $300,000,000 worth of agricultural products every year; and with a situation which causes large manufacturing concerns to consider leaving the State and going to the Mississippi Valley or to the south where food products and labor are cheaper, little argument need be made that Massachusetts needs more rather than less agricultural development.

The passage of the Smith-Lever act by Congress in 1914 gave to the college an initial appropriation of $10,000, with annual increases based on the proportion that the rural population of Massachusetts bears to the rural population of the United States. Due to the form of town government prevalent in New England, the annual increase to this State is $2,443. Some of the other States benefiting under the same provisions of this act will receive additional annual appropriations of the following amounts: —

Alabama,	$17,911
Arkansas,	13,900
Georgia,	20,978
Illinois,	21,902
Indiana,	15,786
Kentucky,	17,573
Missouri,	19,196
Mississippi,	16,108
New Jersey,	6,383
New York,	19,536
Pennsylvania,	30,744
Tennessee,	17,688
Texas,	29,975
Massachusetts,	2,443

Since these amounts must be matched each year with State appropriations, these States will be receiving for extension work at the end of ten years from $250,000 to $550,000 each. Massachusetts will receive a total of $30,000.

It is obvious that if extension work is to be carried on in Massachusetts which will be comparable to that in other States provision must be made for this through State appropriations.

2. Additional Help to carry on the Work.

The need is even greater than in past years for the development of several new lines of work, and for better support of some of the projects already started.

Among the extension specialists most needed are trained men for work in agronomy, injurious insects and plant diseases, beekeeping, agricultural engineering, a man to work with the Homestead Commission, a trained man to work with foreigners who are taking up farms, a specialist to organize extension schools, fair exhibits, lecture courses, etc., and an adviser to the State institutions for help in handling their agricultural projects.

More assistance is needed in junior extension club work, fruit growing, correspondence courses, home economics, poultry husbandry, farm management demonstrations, dairying and animal husbandry, rural organization work and a larger clerical force.

The cost of maintaining this much-needed work would be from $40,000 to $50,000 a year in addition to what is now being appropriated. Detailed estimates of this have been rendered in the reports of the director of the Extension Service for 1914 and 1915.

3. Problems of Adjustment and Relationships.

There are problems of adjustment and relationships still to be worked out between the college, the State Board of Agriculture, the State Board of Education, and other official organizations, but present indications are that these matters will be properly adjusted in the near future.

The relationships of the extension specialists of the college to the county agents is a problem which is being rapidly solved, and when county agent work becomes more firmly established, and with a few more years' experience in developing the work, these relationships will be easily adjusted.

There are still relationships to be worked out with the departments in the college itself, and with the United States Department of Agriculture, but each year finds the scheme of organization more firmly and satisfactorily established.

Nothing which has been said should convey the impression that the organization of extension work in this college has in any way been perfected. We are only in the beginnings. Much progress, however, has been made within the year. A complete reorganization of our work into sections co-ordinate with junior extension and county agent work may be the next step, but little can be done until there is some relief from the stringent financial situation in which the work now finds itself. The college through its Extension Service will no doubt function more and more as an organizer and administrator of large, State-wide movements designed to affect the rural life of the State.

It is to be hoped that the work which has been developed during the past seven years has proved its value, and that in the near future needed funds will be provided to take care of the ever-increasing demands for more assistance.

4. Training of Men for Extension Work.

The need is felt more than ever before of some provision whereby men and women may be better trained for service in the extension field. Good positions are increasing in number. As the work develops, persons of better training than formerly are demanded. Schools of business administration connected with the large universities are beginning to offer courses training for agricultural extension work. There is danger of the Agricultural College falling behind these other institutions. This college, and other agricultural colleges too, should organize and offer courses which, aside from giving the best of training in technical subject-matter as a foundation, would also offer opportunity to students to secure information on extension work and in methods of presentation and in practice work.

Looking over the work of the year, and the evident progress which has been made, one can truthfully say that at the present time extension work is organized on a fairly satisfactory basis in Massachusetts. The Extension Service within the college articulates with the other activities of the college and of the experiment station. Harmonious relationships exist between the United States Department of Agriculture, other State organizations and the county farm bureaus. Differences of opinion as to which lines of work are most important, and the best methods of doing the work, will always exist, but these are being worked out in a frank and friendly spirit.

I wish, as in former years, to mention and commend the spirit shown by members of the Extension Service staff and the untiring energy which they put into developing their work. As I look over the extension work of other colleges I fail to find a corps of workers more devoted to their tasks or more loyal to their institutions than are the men and women who make up our staff.

Respectfully submitted,

WILLIAM D. HURD,

Director.

FINANCIAL STATEMENT.

Report of the Treasurer on Extension Service Funds for Fiscal Year Dec. 1, 1915, to Nov. 30, 1916.

Disbursements and Receipts.

Classification.	Disbursements.	Receipts.	Apportionment.	Balance.
Administration,	$1,502 91	$92 05	$1,700 00	$289 14
Director's office,	1,263 32	44 28	1,300 00	80 96
Salaries,	29,646 19	121 67	29,862 59	338 07
Correspondence courses,	1,078 64	696 96	200 00	—181 68
Civic improvement,	1,310 16	986 11	450 00	125 95
Community planning,	697 86	2 25	550 00	—145 61
Library extension,	199 93	-	200 00	07
Lectures,	221 23	1 00	500 00	279 77
Exhibits,	1,250 26	525 00	500 00	—225 26
Equipment,	704 91	-	1,800 00	1,095 09
Pomology,	284 54	88 20	400 00	203 66
Printing and publicity,	967 09	134 92	1,000 00	167 83
Animal husbandry,	230 22	2 00	350 00	121 78
Agricultural education,	2,386 27	53	2,300 00	—85 74
Farm management,	397 26	109 50	100 00	—187 76
Poultry husbandry,	99 21	9 78	150 00	60 57
Home economics,	354 81	-	350 00	—4 81
Short courses,	11,520 87	2,805 78	9,220 00	504 91
Dairying,	71 91	-	200 00	128 09
County and local agents,	463 65	24 20	520 00	80 55
Agricultural economics,	690 62	17 79	600 00	—72 83
Reserve and emergency,	-	-	9,357 14	-
State Treasurer,	-	50,000 00	-	-
Totals,	$55,341 86	$55,662 02	$61,609 73	$2,572 75
Balance at beginning of fiscal year Dec. 1, 1915,	-	11,719 54	-	-
Balance on hand Dec. 1, 1916,	12,039 70	-	-	-
Totals,	$67,381 56	$67,381 56	-	-

Summary.

	Disbursements.	Receipts.
Balance Dec. 1, 1915,	–	$12,622 56
Receipts Nov. 30, 1916,	–	5,662 02
Received from State Treasurer,	–	50,000 00
Received from United States Treasurer,	–	14,151 90
Disbursements to Nov. 30, 1916,	$69,883 31[1]	–
	$69,883 31	$82,436 48
Bills receivable Dec. 31, 1915, deducted,	–	152 00
Bills payable Dec. 1, 1915, deducted,	594 31	–
	$69,289 00	$82,284 48
Bills receivable Nov. 30, 1916,	–	622 12
Bills payable Nov. 30, 1916,	116 87	–
Balance,	13,500 73	–
	$82,906 60	$82,906 60

[1] Includes Federal Smith-Lever fund.

Report Smith-Lever Funds July 1, 1915, to June 30, 1916.

	Federal Smith-Lever.	State Smith-Lever.
Dr.		
To receipts from the Treasurer of the United States and from State sources as per appropriations for fiscal year ended June 30, 1915, under act of Congress approved May 8, 1914 (Smith-Lever act).	$12,930 75	$2,930 75
Cr.		
By salaries,	$8,460 24	$1,965 47
Labor,	142 47	45 00
Printing and distribution of publications,	532 98	16 50
Stationery and small printing,	261 98	81 66
Postage, telegraph, telephone, freight and express,	36 75	30
Heat, light, water and power,	–	–
Supplies,	40 95	46 70
Library,	–	–
Tools, machinery and appliances,	–	–
Furniture and fixtures,	5 56	–
Scientific apparatus and specimens,	–	–
Live stock,	–	–
Traveling expenses,	3,449 82	775 12
Contingent expenses,	–	–
Totals,	$12,930 75	$2,930 75

Classification.	Smith-Lever Funds.	
	Federal.	State.
Pomology,	$999 38	-
Printing,	501 70	-
Animal husbandry,	748 55	-
Junior extension work,	976 11	$2,103 64
Farm management demonstrations,	983 04	-
Poultry husbandry,	2,437 22	-
Home economics work,	2,754 27	-
Dairying,	1,018 91	-
Extension schools,	538 57	-
County agent work,	1,973 00	827 11
Totals,	$12,930 75	$2,930 75

SUMMARY OF STATISTICS OF EXTENSION WORK FOR THE YEAR.

	Number.	People reached.
Extension Service Staff:[1] —		
Specialists at college,	16	-
Heads of departments (part time),	9	-
County agricultural agents,	14	-
County home demonstration agents,	4	-
Clerical staff,	15	-
Correspondence statistics: —		
Single letters written,	32,470	-
Form letters written,	169,810	-
Bulletins mailed singly,	75,583	-
Total number of names on regular mailing list,	25,000	-
Active enrollment correspondence courses Dec. 1, 1915 (persons),	759	759
Persons enrolled during year,	498	498
Plans prepared for town improvement,	100	-
Communities in which organization work is being done,	34	-
County development conferences held,	4	-
Libraries receiving books through library extension,	39	-
Volumes sent out,	679	-
Lectures given by extension staff,	634	140,292
Conferences held by extension staff,	528	3,015
Visits made by extension staff,	299	4,831
Demonstrations given by extension staff,	108	4,795
Lectures given by college and station staffs,	125	12,493
Number of fairs visited,	8	-
Persons passing judgment on cows,	2,162	2,162
Persons visiting tent,	132,500	132,500
Demonstration orchards under supervision,	15	-
Dairy improvement associations,	3	-
Stock judging contests,	14	-
Boys entered in contests,	244	244
Counties doing boys' and girls' club work,	13	-
Towns and cities doing boys' and girls' club work,	359	-
Club members,	48,421	48,421
Farm records taken,	254	254
Farm records returned,	640	640
Farm accounts started,	286	286
Flocks tested for white diarrhœa,	38	-
Fowls tested for white diarrhœa,	6,376	-
Canning and home economics school,	1	399
Sewing school,	1	32
County home demonstration agents placed,	3	-
Assisted with milk shows,	3	-
Agricultural extension schools,	10	1,050
Community organization schools,	2	120
Farm bureau work: —		
Number of counties organized,	10	-
Number of special districts,	1	-
Number of co-operative exchanges,	30	-
Publications: —		
Number issued,	54	-
Total number of pages,	468	-
Total number of copies,	201,500	-

[1] Salary paid from extension funds wholly or in part.